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ABSTRACT

The papers compiled here were presented at the fourth symposium in a series designed to provide a continuing introduction to current aspects of occupational safety and health. The papers represent eight topics: (1) special health programs, (2) degenerative disease and injury of the back, (3) job stress and work performance, (4) role of industry in preventive cardiology, (5) toxic compounds in industry, (6) emergency medical planning and industrial disaster, (7) industrial toxins and the community, and (8) problems in occupational health programming. Some representative titles of papers included under each of these areas consecutively are as follows: (1) How to Establish an Employee Health Service in a Reluctant Hospital; and Occupational Medical Support of a Research Hospital, (2) Examination of the Lumbosacral Spine; and Biomechanics of Manual Materials Handling and Low-Back Pain, (3) Variables in Occupational Stress; and The Stress of Relocation-Recognition and Prevention, (4) Exercise Prescription in an Industrial Fitness Program; and Cost Effectiveness in Hypertension Management, (5) Principles and Practices of Industrial Air Standards; and Contributions of the Industrial Hygienist, (6) A Pre-Triage System for Mass Casualty Care; and Electrical Injuries, (7) Arsenic Contamination Near a Copper Smelter; and The Michigan PBB Incident, and (8) The Role of Nursing in Occupational Medicine; and The Benefit-to-Risk Ratio in Occupational Health. (EM)

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1977

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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FOREWORD

This 1977 Symposia is the fourth volume in a series resulting from cooperation between the National Institute for Occupational Safety and Health and the American Medical Association in coordinating the dissemination of occupational health knowledge within the general health care field concerning American workers and their families. It is hoped that these proceedings will enhance the delivery of occupational safety and health services.

The symposium brought together persons pre-eminent in the field of occupational safety and health who, by their generosity in sharing their knowledge, provide a continuum on the state of the art in the field of occupational safety and health.

We invite your critical review of these proceedings and would appreciate your comments.

J. Donald Millar, M.D.
Assistant Surgeon General
Acting Director, NIOSH

PREFACE

This publication contains major papers presented at the 37th AMA Congress on Occupational Health as edited for publication by AMA staff.

This is the fourth Symposium in a series designed to provide a continuing introduction to current aspects of occupational safety and health. The information contained herein is significant not only to part-time occupational physicians and nurses, but also to multi-specialty group practices, private practitioners, medical and nursing students, industrial hygienists, safety professionals, and all others interested in the provision of a safe and healthful work environment. Publication by the National Institute for Occupational Safety and Health extends this knowledge to the thousands of interested persons for whom the only available source of this information is this text.
These proceedings do not necessarily represent the views of the National Institute for Occupational Safety and Health, but they do reflect the Institute's concern for improving the delivery of occupational safety and health services. This series of proceedings constitutes a valuable reference for use by those involved in the field of occupational safety and health.

As always, suggestions and comments for future Symposia are invited. Additional copies of the proceedings are available from the National Institute for Occupational Safety and Health, Division of Technical Services, 4676 Columbia Parkway, Cincinnati, Ohio 45226, mail stop C18. Professors wishing multiple copies for use in their classrooms should direct their requests to the Project Officer.

Loren L. Hatch, DO, PhD

ABSTRACT

This volume consists of papers presented at the 37th AMA Congress on Occupational Health, cosponsored by the National Institute for Occupational Safety and Health (NIOSH) at St. Louis, Missouri in September 1977. The proceedings are published by NIOSH. The topics include: Special Health Programs; Degenerative Disease and Injury of the Back; Job Stress and Work Performance; Role of Industry in Preventive Cardiology; Toxic Compounds in Industry; Emergency Medical Planning and Industrial Disaster; Industrial Toxins and the Community; and Problems in Occupational Health Programming.

The 1977 AMA Congress was supported by a NIOSH-CDC Cost-Sharing Contract #210-77-0088.

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The National Institute for Occupational Safety and Health is most appreciative of the work that Theodore C. Doege, MD, MS, Principal Investigator, Director of the American Medical Association's Department of Environmental, Public and Occupational Health, and Robert H. Wheater and Barbara S. Jansson of the same AMA Department performed for these proceedings. Further acknowledgment is due not only to the individual authors who presented papers, but also to all those who took part in the often lively discussions.

Also acknowledged are contributions by the following NIOSH personnel: Jane Lee, Occupational Health Nurse Consultant, Paul Pedersen, MD, MPH, and Elva Elesh, MD, who gave of their time to provide cognate review and offer suggestions for improvement; Gayla M. Osborne and Ann Battistone for their support services; and Gerald Karches, Lorice Ede and Carol Browning for publications assistance.

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STUDENT, HOSPITAL, LABORATORY

Introduction

Bruce E. Douglass, MD

We are delighted that for your delectation and enlightenment we are able to present this morning a panel of experts in several of the specialized areas of occupational medicine. Organizers of the Congress decided that a full round of attention should be given this year to problems associated with the delivery of occupational health services to employees of hospitals and ~~to student~~ groups of colleges and universities. It has dawned on many of us that good conscience no longer allows us to escape the clear and present need for adequate first-line medical attention to these two groups of health care consumers.

Those of us who are concerned with the medical problems of employees of hospitals and clinics have long been embarrassingly aware that medical services to our clients lag miserably behind those offered to employee groups of other businesses and industries. This has been ironic because one could quite properly ask, "Where else but in a hospital or clinic can one reasonably expect to find model programs for employee health? It has been an amusing pursuit to identify some of the reasons why hospitals and clinics take less care of their people than do steel mills and meat packers. For example, hospital management may believe that since the building is full of doctors and nurses, employees can get good medical advice in almost any corridor. This is, however, a most reprehensible kind of medical practice in which proper examinations are not done and no records are made of the advice or results of treatment. Indeed, such free care and professional courtesy may actually hide the need for properly organized health services. Further, it might be implied that clinics must be safe places in which to work by virtue of the nature of their services. The contrary is really true, since electrical radiation and biohazards abound. General hospitals have well over 200 Job classifications, covering the entire spectrum of human capability--from janitor to clergyman and from micrometry to drayage. Many jobs impose unusual stresses and a multitude of health hazards. These institutions should indeed be model programs of preventive medicine. Fortunately, hospital management is gradually coming to realize that indifference toward employees' health is more expensive than providing suitable health services. Hospitals' deficiencies in occupational health are the more lamentable because of the relative ease with which such services can be offered; there are already present and active on the scene knowledgeable persons, records systems, diagnostic and therapeutic facilities, and institution-wide appreciation of the nature and effects of illness.

Recently NIOSH undertook a major study of health services for hospital employees. About 3,500 hospitals were chosen for the survey, from which a body of information was eventually published in a seven-volume set. The mountain of data was further reduced in size to a yellow pamphlet called "The Hospital Occupational Health Services Study." This remarkably thorough piece of work gives us a bird's-eye view of current practices and the state of development of health services for hospital employees.

It was alarming to note that about 50% of the hospitals studied had no formal in-service training in the avoidance of infection or irradiation, or in the use of personal protective equipment. The NIOSH study calls on hospitals of all sizes to develop programs of safety and health education.

NIOSH recommends that hospitals develop model systems for the recording and reporting of occupationally related diseases and injuries. Interestingly the survey showed that almost half of our hospitals make no record of on-the-job injuries or of employee visits to the emergency room, health nurse, or out-patient service. Though illness was expected to be the most frequent cause of absence from work, the second most frequent cause was family health problems. The unexpectedly high incidence figure of the latter may reflect that there is a preponderence of female employees in hospitals, many of whom have children at home. Among those hospitals that kept records, respiratory and other infections ranked first and second, respectively, followed by dermatitis. Strains and sprains were the most frequently reported types of occupational injuries. Puncture wounds came second.

Only about 10% of the reporting hospitals had formally organized employee health services; the remainder utilized emergency room personnel for the management of employee illness and injury. Most of them indicated that their employees are required to see a physician or nurse before leaving the hospital because of an illness or injury, but surprisingly, less than 60% of all hospitals required check-in by a physician or nurse upon recovery. Modern record keeping requires good accounting for all occupationally related injuries and illnesses; and if the emergency room nurse or some other person is asked to provide this function during off hours, she should turn in her records to a central authority first thing the next morning.

Although I suppose any good nurse or physician can learn to provide occupational medical services, it can't be denied that occupational health requires a special interest and a special orientation. The practitioner must be on the side of the patient in every way. Yet he must also represent the best interests of management and have a commitment to the smooth running of the common enterprise. It is unproductive and wrong to ask general duty nurses or physicians to participate in a disorganized occupational medical function. Only when one or several individuals are given this responsibility can there be any hope for proper medical services to the employee group. The larger the hospital, the more economically feasible it will be to afford such specific assignments; but even in small hospitals, an interested nurse or physician can usually be found who will be willing to undertake and develop a systematic method for the disposition and surveillance of occupational medical problems. Then and only then can one have smooth organization, adequate records, reduction of absenteeism, proper referral of cases requiring further study or treatment, and proper relationships with private physicians.

The occupational health nurse who through training and indoctrination understands the ethics and principles of this specialized field of nursing is the key individual. She should be skilled in counseling with respect to work stresses, be able to treat minor disorders and to make wise referral of major health problems. Either in person or by frequent telephone contact, she should ensure that sick employees receive medical care of high quality. She should be backed up by an interested physician who should himself become well acquainted with the hospital environment and the hazards it presents. He and the nurse must be continually mindful of the need for scrupulous attention to confidentiality of medical information; and as a team they must develope, earn, and maintain a flawless reputation for dependability.

To be sure, supervisory persons must occasionally be apprised of an employee's medical problem. In such cases, it is our practice to obtain the approval of the employee and make the necessary disclosures in his presence so that he will know first hand the exact nature of his disorder.

Perhaps even more complex and varied in its challenges to the health team than the hospital and clinic health services is that of colleges and universities, some of which are now "megaversities" with tens of thousands of students and staggering numbers of faculty and staff. Our total University of Minnesota community in Minneapolis alone comprises nearly 90,000 people. Many factors that are peculiar to this kind of community conspire to create a unique set of health problems and challenges of crowded conditions, anxiety over studies and examinations, impoverishment of many of the students, "junk" foods, the freshman's first sortie into personal independence, and many other factors. As to dispersion, college health concerns range from the tiny community college of 200 students, most of whom live at home, to special project situations, such as research stations, in which a few persons live in extreme conditions in remote locations. Not surprisingly, college health services have grown up along variable lines with differing philosophies as to the degree of responsibility for student health and wide variations as to the extent of services offered.

Providers of college level health services have banded together in the American College Health Association, an organization based in Evanston, Illinois, which sponsors conferences, research, and publications, and whose latest revision of "Recommended Standards and Practices for a College Health Program" provides much helpful information.

SPECIAL HEALTH PROGRAMS: STUDENT, HOSPITAL, LABORATORY

How to Establish an Employee Health Service in a Reluctant Hospital

Cynthia A. Hunstiger, RN

In 1977, the emphasis is on cost containment; hospitals do not want to incur expenses that will increase patient costs. The federal government's proposed ceiling on hospital price increases will make it difficult for them to spend money on employee health without evidence that better patient care will result. How does this affect you as an occupational physician? You may have the task of addressing this concern and convincing your hospital administration that a comprehensive employee health service is cost-justified. In that event, there are a number of considerations that can affect your ability to develop an employee health service in a reluctant hospital.

Take the time to learn about the hospital and talk with the administrators. Find out what the goals of the institution are. Identify the sources of revenue and the types of programs they spend money on. It is especially important to investigate the employee benefit programs. Hospitals pride themselves on these programs. How much emphasis, however, is placed on health? Do they provide life insurance, but no health service? An employee health service is a benefit for the hospital as well as a benefit for employees. One benefit to the hospital is the reduction of insurance costs. It will help you to know how workers' compensation is administered and how the premium rates are determined. The more money that is paid out in claims, the more that will be charged to the hospital in rates during the following years. In Minnesota, insurance companies have asked for a 200% increase in rates and they will probably go to the state legislature to get it. Therefore, there is tremendous interest in programs that will decrease the number of claims against WC insurance. Saint Marys Hospital has reviewed its insurance claims payments and found that it can save money by absorbing claims under $150.

One of the programs initiated by the health service at Saint Marys is a program to ensure reporting, evaluation, and proper treatment for occupational injuries. This program has had very positive effects in addition to cost savings and fewer WC claims. The Employee Health Service is assisting Saint Marys in meeting OSHA requirements as well as providing for increased awareness of safety and evaluation of the causes of commonly reported injuries. Easy access to prompt medical care also decreases the more costly complications of injuries; employees are receiving the proper medical treatment for their injuries and are able to return to work sooner. Emphasis on injury prevention is also aided by evaluation of the employee's physical capability to do his particular job.

If your discussions with the hospital administration indicate that costs are a concern, how do you convince them in terms of "dollars and cents" that employee health care will be cost-effective? Too few occupational physicians have paid attention to the accounting aspects of medical care. As a result, there has been a lack of data at their finger tips for convincing administrators that they are paying more money for less comprehensive and efficient health care in a poorly developed employee health service program.

It may take much effort, but if you can retrieve data on the following:

1. lost work time due to injury and illness,
2. travel and waiting time to visit an off-site medical facility,
3. overtime wages to cover absenteeism,
4. wages for unjustifiable illness and abuse of sick pay,
5. payments for workers' compensation claims,

The result will be an eye opener for the hospital. All of these losses can be effectively reduced by the establishment of a comprehensive employee health service that is readily available to its employees.

Your next concern is yourself. What are you able to offer? Examine your goals and experience in occupational health. Then put together a program that answers the cost concerns of the hospital and is one that you can "sell." Educate your hospital administration about employee health by making them and yourself aware of the scope and objectives of an employee health service and the recommendations made by NIOSH, AMA and the AHA. The AMA provides a pamphlet entitled "Guiding Principles for an Occupational Health Program in a Health Care Institution, Revised 1977"; this is a joint statement of the AHA and AMA. Saint Marys Hospital adopted a resolution to develop a program to meet these recommendations. If marginal services now exist, use the recommendations for an evaluation of the present program. Mandatory federal standards for hospital health services will eventually issue in addition to the AHA accreditation requirements. In the interim, convince your hospital that it will be beneficial to have high quality health standards for their employees now.

How does one go about developing a health service program and what role does the occupational physician play in the development? From the experience at Saint Marys, I recommend that a planning committee be appointed by the administration. This working body not only contributes individual expertise, but also lends authority and influence to support the programs once they are made part of hospital policy. If available, the occupational physician should be a member; in addition, the committee is composed of an assistant administrator, the director of personnel services, the health service supervisor, the director of the hospital-sponsored LPN training school, an assistant director of nursing service and two additional department heads. This cross section of interests and responsibilities should provide adequate input for the planning process.

Saint Marys decided to expand its health service programs for employees in 1973. The major services instituted since then involve:

1. pre-employment physical examinations,
2. treatment of occupational injury/illness,
3. expanded immunization,
4. annual tuberculosis surveillance,
5. rubella screening,
6. preventive health maintenance (e.g., weight reduction instruction),

7. health education (e.g., BSE, cancer and hypertension),
8. special projects (e.g., annual screening clinics for vision, hearing, hypertension, diabetes, and glaucoma),
9. infection control,
10. personal assistance to ill and absent employees,
11. information and referral service.

How do you answer an administration that says it doesn't need an employee health service program? After all, the modern hospital is identified as a place of restoring health. One does not expect that its employees are going to be sick. There is even a common attitude, especially among nurses, that they can take care of themselves. Moreover, the practice of "corridor consultation," which is used in connection with health care for hospital employees, may have contributed to the attitude that hospital employees do not need health service programs. Why should the hospital establish a central health service if its physicians are willing to treat employees "off the record"? But staff physicians who are willing to treat employees without the benefit of records, actually are doing the employees a disservice. "Corridor consultation" is unsafe and should not be permitted, and the physicians themselves should make clear their views about the liability of this practice and the potential for malpractice suits.

The "corridor consultation" dilemma also serves to emphasize the importance of recordkeeping for hospital employees. Establishment of employee health records was one of the most important contributions of Saint Marys Health Service. They provide for a medical history that can be reviewed when discussing health problems with the employee. They are useful in counseling, in dispensing medications, and in evaluating the health of employees over the period of employment. Inasmuch as many of the hazards of the hospital as a work environment are still being identified, the records are an asset in the evaluation of hazards and also a protection to the hospital against false claims of occupational exposures.

One intangible but very rewarding result of the expansion of the employee health service programs is attitudinal for both employees and the hospital administration. Saint Marys administration has recognized the principles of employee health and has come to realize the benefits of policies that have been enacted. Employees know that Saint Marys is concerned about their health, enough to provide the employee health service as a benefit for them. Employee reaction has been very favorable and they appreciate and participate in our programs.

In the six months prior to the reorganization of the health service in 1973, the average number of employee visits and telephone calls to the nurse was 116 per month. During January through June of 1975, a monthly average of 449 employee visits and telephone calls were recorded. Most recently, during January to June of 1977, the average increased to 1,244 employee visits and telephone calls each month; 14,302 employee visits and telephone calls were recorded in the last annual report. These statistics do not reflect the number of visits made to the occupational health nurses by students of the hospital-affiliated educational programs. Nor do they include visits by employees or students to the health service physician. One wonders where, or if, these employees would have obtained assistance if our employee health service did not exist.

In summary, administrative support is the key to successful development of a health service for hospital employees. Some administrations are unaware of the value of and need for employee health programs. However, even those who are aware of the advantages may still be reluctant to invest time and money in employee health programs such as those outlined and recommended by NIOSH. However, as you can see from the experience of Saint Marys, it is possible for you to sell the need.

SPECIAL HEALTH PROGRAMS: STUDENT, HOSPITAL, LABORATORY

Problems in the Management of College Students' Health

John M. Miller, MD

When I first became professionally involved in college health work a little over 23 years ago, the term "college student" needed no explanation as to what was meant, nor was there much misunderstanding about the type of environment in which that individual was living. There was a significant homogeneity to college students and institutions of higher education. That is no longer true! We now have students with wide ranging ages and motivations, receiving education in an even wider range of settings, from the "hallowed halls of ivy," through the plethora of community and junior colleges, to independent study at the student's own place of employment.

In my judgment there is not a great deal that is unique about the medical problems of students. This is perhaps less true in the case of mental health, and I will get to that; but for the most part, the medical problems of college students are those you would expect to see in that age group. Parenthetically, I want to dissuade anyone of the thought that the traditional college student age group does not have serious diseases. For one of the challenges of college health work is to be alert to significant pathology in an otherwise healthy young adult.

If then the types of medical problems of college students are not all that unique, it is the manner in which they are managed that certainly varies. Obviously, a part-time student in a small urban community college who is employed somewhere on a full-time basis, will be managed differently from the one who is enrolled full-time in a large residential university in a rural setting. Their needs are not too different. The 19-year-old, whether working in a factory, living at home and commuting to school, or living in a fraternity or large rural campus, is in the process of developing his own independence and identity, and the ability to deal with authority and sexuality. How his needs will be met, if indeed they are met at all, will depend on the resources available to that student and the philosophy of the people who manage those resources.

Since most of my experience has been with a college health service at a large residential, semi-rural, state-supported institution, I would like to highlight what I see as some of the major concerns in that type of program.

The role of a college health service in disease prevention and health promotion cannot be over emphasized. College health services have been involved in this aspect of health programming for some time, long before national publicity began to make it popular. Programs of immunization, disease control, and early disease detection have been moderately effective. But those programs aimed at health as a positive value in life have had disappointing results. Nevertheless, the obvious benefits of programs that will lower the incidence of cigarette smoking in our young adult population is exciting; as well as programs that lead individuals to maintain a healthy weight, or to improve their cardiovascular fitness, or to use alcohol intelligently. The list could go on and on. The need is apparent; the challenge is to develop programs that are effective.

The key to adequately dealing with effective health promotion is the increasing involvement of students with their health program. As Dr. Phillip Chase, Director of the Tufts University Health Service noted in 1971 (1):

> "No longer are students passive receivers of educational processes promulgated by their elders. They are, more and more demanding to be heard and made partners in the serious business of getting an education. As their numbers increase and their voices become louder, college administrators are beginning to listen and to find in student ideas and opinions much forward thinking, common sense, ideas and opinions not as far-out or revolutionary as was first thought."

This has not been an unmixed blessing. Nevertheless, I believe very strongly that responsible student involvement, not only improves the program, but perhaps more importantly, it has a positive educational impact on students' expectations and utilization of health resources. And need I remind you that today's college student is tomorrow's potential community leader?

Another unique concern in college health programs is mental health. A college student is introduced to new stresses while the normal ones are usually magnified. Thus a good mental health program can make a very positive impact. It has been estimated that 10% to 15% of the college students need some assistance each year from a mental health professional. The Recommended Standards and Practices for a College Health Program, developed by the American College Health Association (2), notes that,

> "Many...students can be helped effectively by brief contact with professionals who have a clear understanding of the psychodynamics of young adults. The further development of many potentially disabling emotional problems can be prevented if they are recognized promptly and if skilled treatment is readily available under circumstances which encourage use. On the other hand, delay in prompt recognition, treatment, and rehabilitation of students who have such problems may seriously compromise the productivity of their college experience and lead to more prolonged and serious disability."

Of course, the need for counseling in sexuality, including pregnancy, must also be met.

Dr. Dana Farnsworth, former Director of Health Services at M.I.T. and later at Harvard, has suggested that the need to contribute to the attainment of emotional maturity is one of the tasks of education (3). He has identified ten goals of education to which a college mental health program should contribute:

"1. Respect for all persons, regardless of their race, color, ethnic background, religion, or behavior at the moment.
2. Sufficient knowledge of other people to be able to judge in a general way what their needs are, the ideals they honor, the customs they practice, and the frustrations they endure.
3. Knowledge of the qualities required in a person who can be at home with diverse groups of people and yet be able to enjoy being alone.

4. A sensitive and perceptive awareness of one's own nature, both those qualities under the control of the will and those which are not.
5. Sufficient modesty and humility not to feel impelled to impose one's own ideas on others.
6. The achievement of a proper balance between self-regard and a concern for the welfare of others.
7. The ability to appreciate how one's own self is perceived by others, thereby enabling the individual to modify his own actions continually in order that he may increase his competence and capacity to relate to others.
8. The quality of being able to disagree with others without becoming angry; a conviction that differences of opinion should be settled by the power of rational authority rather than by force, whether verbal or physical. At the same time the value, even the necessity, of righteous (or judicious) indignation should be realized.
9. The habit of inquiry and doubt, practiced in such a way as to avoid becoming either a fanatic who sees simple solutions to complex issues or a cynic who sees no merit in any constructive activity.
10. Capacity to formulate the nature of problems not yet apparent together with some idea of how to plan the development of appropriate solutions."

One more concern of college health programs that I would like to touch on is athletic medicine or, as it is better known, sports medicine. A college's or university's responsibilities in this area are considerable. When this subject is raised, one frequently thinks first of the institution's intercollegiate athletic program; indeed, this is where much of the attention is focused. A galaxy of postgraduate and continuing education courses, not to mention a large number of books, have been devoted to the medical aspects of interscholastic athletic programs. But the institution cannot forget the medical aspects of its physical education program, its intramural program and even its informal sports program. The need to be involved in conditioning and rehabilitation is apparent. Thus the field of sports medicine has almost unlimited potential.

Doctor Farnsworth concludes his paper on college health in The New England Journal of Medicine with this summary (4):

"Health Services in the colleges and universities of the United States and Canada have made important forward strides, especially in the last three decades. Recognition that the health of students and faculty is a matter of importance in an educational sense as well as a personal one is growing. Accordingly, colleges have attempted to build health in positive ways in addition to attempting to see that students and faculty get the best possible medical treatment. These measures include programs of tuberculosis control, immunization against communicable disease, research, mental hygiene, environmental sanitation, safety, prepayment and insurance plans, and cooperation with all other college departments on health matters. Student medicine is not a separate specialty, but does call for a special point of view regarding specific problems of a more or less limited age group. In fact, those who enter this field full time are forced by circumstances to go in the opposite direction from specialism to a considerable extent and to become general medical advisers."

While the import of that statement is current, it is significant to note that it was written 24 years ago. The second class image of college health programs has been allowed to persist far too long. Health professionals in this field have much to say, be it specific medical problems or more generally, health care delivery. It will be a shame if this group is not heard.

In conclusion, I want to call your attention to the goals of a comprehensive health program for the college community developed for the Fifth National Conference on Health in College Communities (5). They are:

"1. To promote and maintain those conditions which will permit and encourage each individual to realize optimum physical, emotional, intellectual and social well-being.
2. To anticipate and control those factors in the community and its environment which may compromise this well-being.
3. To guide the individual in the acceptance of health as a positive value in life.
4. To stimulate the capacity of the individual to make healthful adaptations to the environment."

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SPECIAL HEALTH PROGRAMS: STUDENT, HOSPITAL, LABORATORY

Occupational Medical Support of a Research Hospital

Robert J. Brandt, MD

INTRODUCTION

The Occupational Medical Service Unit at the National Institutes of Health (NIH) in Bethesda, Maryland has been in existence for approximately 30 years. The concept of health services for employees has a long background and tradition. The program that I would like to outline at this time in support of a research hospital is that which is specifically provided to employees of the NIH Clinical Center, beginning with its opening in 1953. Formerly named the Employee Health Service, in July of 1976 the unit name was formally designated as the Occupational Medical Service.

The Occupational Medical Service comprises a large separate unit located within the Clinical Center structure. Also, four satellite health units are located on the campus and at outlying facilities occupied by NIH personnel. In addition to occupational medical support to the hospital, the program includes support to the administrative and laboratory missions of NIH, made up of some 12,000 employees. The Occupational Medical Service employs 23 persons including 5 full-time physicians, 11 nurses, 1 laboratory technician, and 2 occupational medical technicians.

The Clinical Center is a large, single structure encompassing 516 active clinical beds with laboratory space comprising approximately twice the space occupied by beds. About 4,000 employees work daily in 1,100 laboratories and in the hospital facility within this single structure. These employees are the usual hospital support personnel as well as researchers and laboratory technicians. Occupational medical support within this environment necessarily includes the laboratories as there is very often overlap between patient care and laboratory research--essentially the unique feature of the NIH setting. No attempt will be made here to present the support of specialized laboratories outside the area of clinical research and clinical care. I will try to show those parts of the program directed towards specific laboratory support as opposed to patient care support so that occupational medical personnel who have one or the other of these missions can apply specific principles and techniques.

An occupational medical service cannot exist as a separate entity in support of an employee population. Administratively the service must be closely tied to the day-to-day decision-making in the hospital hierarchy. In addition, its administration must, through formal committees and informal communication channels, remain in constant contact with all hospital departments. In a large hospital, such as this, responsibilities for environmental monitoring and measurements usually exist as separate organizational entities. In our case, environmental engineering, biohazards, and radiological safety personnel are organized in an environmental health and safety program under the Directorate of Research Services. Frequent discussions and meetings with Environmental Services personnel are required in order to monitor on-going programs and be alert for new requirements. Environmental Services personnel participate with Occupational Medical personnel in the formal meetings of the Hospital Infections Committee and the Hospital Multi-disciplinary Safety Committee.

The following program elements comprise the Occupational Medical Support Program:

1. pre-employment examinations,
2. nonoccupational illness monitoring and limited care,
3. occupational injury and illness care and reporting,
4. surveillance examinations,
5. health education and counseling,
6. medical records and reporting.

Proper coordination of all elements is a necessity whether the program is supervised by a single occupational health nurse or a large professional staff.

PRE-EMPLOYMENT EXAMINATIONS

Pre-employment examinations are done on all prospective full-time employees. Special effort is made to see that all patient care employees, including physicians, nurses, food service, and janitorial personnel, are examined and medically cleared prior to beginning work. All summer program employees are examined prior to employment or as soon as practical at the beginning of their summer jobs. Hospital volunteers are screened only for tuberculosis by skin test or chest film. Most physicians and some researchers are involved in both patient care and the laboratory; these employees are treated as patient care personnel for scheduling and type of physical examination.

The physical examination includes:

1. medical history, reviewed by the occupational health nurse and examining physician,
2. general physical examination with emphasis on evidence of infectious disease, physical incapacity and disability,
3. chest x-ray (PA and lateral),
4. electrocardiogram (for age 40 and over, or where specially indicated),
5. vision (including color perception) and hearing,
6. laboratory tests (i.e., complete urinalysis, hematocrit, and serology),
7. immunity status (especially update of tetanus-diphtheria, smallpox as a routine immunization for our hospital personnel has been discontinued, PPD for tuberculosis as indicated with skin testing with a lower strength PPD performed on BCG immunized individuals and where positivity of reaction cannot be assured).

In addition to the general examination above, laboratory and special patient care personnel receive further evaluation including the collection of a serum sample, which is frozen and stored for further evaluation should an infectious disease or suspected occupational illness develop later. Special considerations are given to immunity status depending on exposure of the individual--for example, Australia antigen and antibody status of phlebotomy teams in the clinical pathology laboratory and blood bank, and specific immunizations for those persons working with viruses (e.g., hepatitis, polio, and rubella).

For an efficient and meaningful pre-employment examination program, continual input is needed from all hospital departments: personnel officers who do initial interviewing and hiring, laboratory directors responsible for the specific content of their research programs, and clinical directors responsible for patient care. The specific departments and user agencies are familiar with the physical requirements of each of their jobs as well as changes imposed by new missions and programs in patient care and research. The Occupational Medical Service must continually review and update these requirements.

NONOCCUPATIONAL ILLNESS MONITORING AND LIMITED CARE

Evaluation and monitoring of acute illnesses, particularly infectious disease among hospital employees and laboratory employees, is an important part of the Occupational Medical Support Program. Policies have been established with the Nursing Service and Food Service departments for evaluation of employees reporting an illness or returning to work after prolonged absence due to illness. The employee is evaluated, appropriate cultures are taken, and treatment or referral to his personal physician is made for resolution of the acute problem.

Occupational Medical Service's nurses and physicians prepare a report on each hospital employee with an infectious disease. The cases are summarized and a report is sent to the hospital nurse epidemiologist for review by the Infections Committee.

Minor illnesses and nonoccupational injuries also receive evaluation and care in the Occupational Medical Service. Such care allows the employee to continue working. The Service cooperates closely with private physicians in providing routine evaluations that may be requested by the treating physician (e.g., x-rays, urinalysis, urine culture, blood count, and limited blood chemistries).

An efficient program of illness monitoring requires established policies for referral to the Occupational Medical Service from the participating hospital departments, such as the Food Service, Nursing Service, Janitorial Service, and Laundry Service. Valuable information is developed on the health of the employee population. This is closely coordinated with the hospital epidemiologist and the Infections Committee for possible implications in patient care areas.

OCCUPATIONAL INJURY AND DISEASE

The Occupational Medical Service provides evaluation and treatment for injury and disease arising from employment in the hospital and laboratory. The occupational health nurse is responsible for completion of an accident survey form on each reported case. Physicians in the Service provide evaluation and full care within limits of their capability. Referral to specialty consultants is necessary in some cases, particularly in such areas as orthopedics, ophthalmology, allergy, and dermatology.

Common among patient-care employees are back injuries; in some instances, prolonged absence from work and assignment to less strenuous patient-care activities on return are required. These "limited duty" assignments require close coordination with supervisors and a firm policy to avoid confusion and motivational problems among employees. The second most common type of accident among patient-care and laboratory workers is the puncture wound caused by needles and broken glassware. These cases require careful evaluation because of potential infection. Laboratory workers are frequently subject to bites of all types, and close coordination with research veterinarians is necessary to provide proper care and follow-up of the worker as well as isolation of the infected animal. Another very common problem among these workers is that of allergy to animal dander. Occupational Medical Services provides allergy referral, evaluation, and desensitization in a weekly clinic. In many instances, laboratory workers have to initiate strict environmental controls to prevent exposure to animal dander.

In the area of occupational disease there are two other potentially serious problems: hepatitis (particularly type B) and tuberculosis. Tubercular patients occur only rarely in the research hospital; most cases are unsuspected until autopsy. Occupational Medical Services maintains the tuberculin skin test status of all patient-care employees. With the identification of a tuberculous patient all contacts are placed under surveillance in a cooperative effort with the Nursing Department and the nurse epidemiologist.

In a research hospital with leukemia services and open heart surgery that require multiple transfusions, the incidence of patients with a known hepatitis B antigen status is extremely high. In the case of exposure to the hepatitis B Virus, the high titer immune globulin (H-BIG) is used when exposure to a contaminated needle or direct, mucous-membrane contact with a proven hepatitis B carrier has occurred. The high titer globulin is not used prophylactically for preventing nonparentally transmitted hepatitis B in our facility. Hospital policies require posting on the ward a list of all patients known to be Australian antigen positive.

Increasing use of cancer chemotherapy and other modalities of immunosuppression leads to additional problems. Immunosuppressed patients may develop terminal herpes zoster, which provides a high risk to patient care employees. In addition, there may be some confusion about the etiology of herpes simplex and the degree of risk to immunosuppressed patients from exposure to employees with such lesions. It is felt that employees with open lesions of herpes simplex should not be in contact with immunosuppressed patients or others with extensive dermatitis; however, there are no other restrictions.

Occupational disease and injury cases require continual cooperation with the hospital compensation carrier; at NIH it is the Federal Office of Workers' Compensation. In addition, close monitoring by Occupational Medical Service physicians and the specialty consultants utilized in such care is required. Epidemiological investigations are conducted in the majority of occupational disease cases and close coordination with the Infections Committee is required.

SURVEILLANCE EXAMINATIONS

Occupational Medical Service performs periodic evaluations on patient care and laboratory personnel who are exposed to recognized environmental hazards. Examination may consist of a complete physical with laboratory profile or a specific laboratory evaluation to measure the biological effects of a specific hazard. Clinical Pathology and Anatomical Pathology personnel are evaluated for infectious disease hazards, such as tuberculosis and hepatitis. A unique exposure recently identified in the Clinical Pathology Department was that of excessive noise in computer rooms.

Examinations for laboratory workers exposed to hazardous chemicals and viral carcinogens are extensive and include a general physical on an annual or biannual basis. Animal handlers, particularly those working with primates, are periodically evaluated for tuberculosis, immunity status to tetanus and rabies, and, where necessary, for preexposure rabies immunization. Handlers who work with animals that are not being bred for research work receive preexposure rabies prophylaxis.

Fire Department and Security personnel are evaluated annually for physical fitness and their capability to perform strenuous activities related to their work. Special consideration must also be given to the Janitorial and Environmental Services personnel who enter all laboratories and clinical areas, including patient areas, since they can be exposed to multiple environmental hazards.

Surveillance exams require continual monitoring through the Hospital Safety Committee and Infections Committee. Chiefs of services, particularly the Laboratory and the Janitorial Services, must continually be queried for changes in their procedures and programs. In the research area, the laboratory chiefs are required to coordinate changes in programs with the Environmental Health and Safety personnel. Occupational Medical Service is in continual contact with these programs to provide current and meaningful surveillance evaluations.

HEALTH EDUCATION AND COUNSELING

Occupational Medical Service cooperates with the Safety Committee and section chiefs in providing health information to all new employees. Laboratory safety, while primarily the responsibility of laboratory chiefs, requires health input in high-risk areas, such as infectious disease and chemical carcinogens.

Occupational Medical Service also provides a mental health program with broad participation at all management levels within the hospital. Orientation lectures in emotional health are provided to nursing care personnel. This orientation is directed specifically at interpersonal relationships on the supervisory level as well as at unique situations in the research nursing care environment. Group sessions with nursing care personnel on the matter of dealing with a dying patient have been conducted.

Alcohol and other addictive drug usage in the hospital or research environment is of particular concern. Occupational Medical Service provides supervisory training for the recognition and handling of these problems. Also, counselors are available for evaluation and referral as well as for continuing individual and group treatment.

These programs are coordinated with the Safety Committee, supervisors of Hospital Services, and Environmental Safety personnel who have responsibility for safety orientation of all employees.

RECORDS AND REPORTING SYSTEMS

Employees' medical records are maintained by the Occupational Medical Service. These records note all examinations, reports of injury and illness, and visits to the Occupational Medical Service Unit, and are kept separate from those of hospital patients in research or treatment programs. Moreover, the system has been computerized so as to provide a monthly report of type and frequency of visit, identification of those accidents causing injury and illness, and scheduling for surveillance examinations and immunization follow-up. All employees are informed about procedures for access to their records under the Privacy Act and that any release of personal medical information to third parties (even where the third party may be the Personnel Department) is not made without the employee's authorization in writing.

And finally, it is interesting to compare our on-going program, which developed spontaneously over the years, with that recommended by the NIOSH Hospital Occupational Health Services study. Although the wording is slightly different, all aspects are covered.

SPECIAL HEALTH PROGRAMS: STUDENT, HOSPITAL, LABORATORY

Health Service Problems

Mary L. Parker, MD

ADMINISTRATIVE MATTERS

The health service in which I work offers medical care to the student body and the entire employee group. There may be need for interaction with academic deans concerning a student's course-work, with housing and food services regarding a student's special housing and dietary needs, with the Athletic Director over a varsity athlete's eligibility or injury, with the Personnel Director regarding an employee's absenteeism or job-related injury, with the Office for Environmental Health and Safety on precautions for preventing injury or illness, and lastly with a committee of students, staff and faculty to deal with an evaluation of and suggestions for the health service. Failure to maintain contact with these various sectors may lead to loss of effectiveness. This is not a simple feat; for while maintaining lines of communication between all concerned parties, it is essential that the patient's problem remain confidential.

For the most part, our staff is composed of physicians newly entering private practice who work on a part-time basis. Most of them work for us six hours per week, some as little as three and a few as much as ten. They are recruited from the residency training program at hospitals associated with Washington University School of Medicine and, in general, they stay with us from three to four years. Eventually, their practices pick up and they can no longer spare the extra time. We have a perennial task of recruiting newcomers to replace our dropouts. This burden is offset by our ability to have up-to-date, well-trained young clinicians who are knowledgeable in the specialties and services of the local hospitals, and who have no difficulty relating to the current college crowd.

Our nursing staff is also unusual in that we have several part-time employees. Many women with growing families may feel that full-time employment is not possible but they are nevertheless available for part-time service. We are thus able to temporarily increase our nursing staff whenever the patient load is heavy and then lower it when the load is reduced.

The financing of a health service remains a matter of concern. The health service that is financed through an allocation from general funds competes with other university departments and can be at a disadvantage when the time comes to balance the budget. A combination of an allocation from general funds to cover the cost of maintaining the physical plant and staff salaries and a fee for certain services has worked well for us. Thus, as the demand for laboratory tests increases, our income increases.

In years past, the university purchased health insurance to ward against the heavy cost of hospital care. However, this insurance did not apply to any of our services; furthermore, the policy had a "coordination of benefits" clause that applied in the event that a student was also carried under his family's health insurance. Over the course of years, it became apparent that the dollar amount of claims paid out was but a fraction of the premiums paid in. Consultations with the University's legal counsel, the State's insurance officer, and the University's insurance coordinator produced a plan that now provides hospital or emergency care as extended benefits of the health service. Identical benefits for a spouse or dependents were provided, if desired, through a private insurance company, and we were able to purchase reinsurance protection for ourselves in the event the claims exceeded the $60,000 per year deductible limit. The outcome has been an increase in protection with a reduction in cost.

Physical facilities of the health service affect the ease with which services can be presented and utilized. Our unit was formerly a dormitory, an old building with a floor plan that left much to be desired, but its location could not be better. It is adjacent to the assembly chapel, the bookstore, the student center, and about 100 yards from the main library. It is readily accessible from the administrative, academic, athletic and residential areas. Renovation of the building has given us a central reception area, records room, surrounding services, and clinics. The reception area is often crowded; however, we prefer the crowding in the present building to the isolation of a new building on the edge of the dormitory complex.

SERVICES

Two internists on 24-hour duty in the out-patient clinic see patients on a walk-in, first-come, first-serve basis. Appointment scheduling for follow-up with internists has not been successful, but we do have a fairly effective system for telephone reports as part of the follow-up. We are able to schedule appointments with the specialty physicians who come to our service. We have a surgeon three times a week, a dermatologist for one morning each week, and a gynecologist for three half-days a week. Each specialist has a nurse as an assistant. In addition, a competent laboratory technician provides "stat" blood counts, urinalyses, smears or stains, throat and urine cultures, and a few blood chemistries. A large midwest clinical laboratory provides pick-up service and 24-hour results for most other diagnostic tests that are needed.

A modest supply of common medications is available at the health service. Otherwise, the student may have his prescription filled by an outside pharmacy, or we can get it for him from our supplier. All medications obtained through the health service pharmacy should be carefully identified as to source, recipient, and identity of the drug. Several years ago one of our "hippie"-type students was stopped by a traffic officer for speeding. His car was searched and an envelope containing Donnatol was found. Had this not contained our identification, his identification, a date, and a prescription number, he would have been arrested for having a supply of "downers."

With over 2,500 dormitory students and over 1,000 freshmen who are away from home for the first time, there is often a need for an intermediate level of care that is comparable to that of a private home. To meet this need, we have a 10-bed infirmary that is open from Monday morning through Saturday noon; it is staffed by registered nurses and a physician who makes daily rounds and is available by phone for evening consultations. At one time this infirmary was open 24 hours a day, seven days per week. However, we soon found that students wanted to return to the dorm area over the weekend; thus, our Saturday and Sunday census was usually very low. This suggested that it would be preferable to hospitalize the rare individual who was not able to return to the dorm by Saturday noon rather than to keep the infirmary open through Saturday and Sunday. There is always a doctor on telephone call and the Emergency Room of our hospital is only two miles away; Security Officers on the Campus are ready to take anyone over who needs emergency care.

Our mental health clinic consists of a full-time faculty member of the Department of Psychiatry assisted by fourth year residents in the Department of Psychiatry training program. This clinic is separated from the general clinic. Students who are unwilling to seek psychiatric care, lest the fact be noted on their academic record, are assured that such records are highly confidential; as such, they are kept and are reviewed or released only by specific written authorization of the patient. Another fear that we face in this area is that our psychiatrists are merely "pill pushers". While it is true that our Department of Psychiatry is pharmacologically oriented (particularly with the depressed patient) we remind the student that each patient is fully evaluated, and medications are not used unless the doctor feels they provide an appropriate addition to psychotherapy.

The Health Service also provides health supervision to the athletic program. Each varsity athlete must have a complete physical prior to participation. This is easy to provide, but to have an orthopedist at all games and for all injuries is another matter. In recent years we have been fortunate to have the major sports teams in St. Louis come to the Department of Orthopedics at the Medical School; this has fostered interest and special expertise in the care of athletic injuries and thus benefits our students.

To alleviate the congestion in our waiting room, of students with very minor problems, a health education and outreach clinic has been established. Each floor of a dormitory has a student "health aide" who is equipped with a first-aid kit and several over-the-counter medications. In addition, the recently published book "Take Care of Yourself" is available on loan to every dormitory student. By this means it is hoped that the very minor problems will be recognized and handled by the student or the health aide; whereas, the serious problems will be recognized and sent to us without delay.

A problem that has long existed among employees and is now being encountered with increasing frequency in the student population is alcohol abuse. A program has evolved that is two-pronged. One is directed toward the employee sector to assist persons whose job performance has deteriorated, whatever the cause. The other prong is directed toward the student group and is, in large part, an effort at education. This program has been titled the "Campus Assistance Program" and is modified after industry's approach to absenteeism and poor job performance.

ETHICAL AND PROFESSIONAL RELATIONSHIPS

Statutes and laws vary from state to state, especially in areas of confidentiality, priviledged communication, minority rights, informed consent, and reportable conditions. Where possible, we try to use the same guidelines for minors that we would use with adults. Our medical records are held in strict confidence; we have even refused to employ students in our center lest they gain access to another student's records. No medical information is shared with administrators, academic persons, or residential directors without the specific written consent of the patient. We encourage students to share any significant medical information with their parents; but only in the case of serious illness or injury requiring hospitalization do we contact the parent or guardian, and an attempt is made to obtain the consent of the student in advance of such notification.

The management of pregnancy of an unmarried minor requires the cooperative effort between the patient, the Health Service and other agencies. It is important that the Health Service maintain a reputation for confidentiality in this area so that women students with personal problems will feel free to seek help.

Students with religious conviction against the use of the Health Service may ask that health requirements be waived. Whenever possible their requests are granted; however, religious conviction does not relieve them of the need to observe public health measures. No attempt is made at medical intervention or indoctrination, but the student must demonstrate freedom from any infectious or contagious disease.

One last note. In this day and age of the Buckley Amendment, any student who requests a review of his record is entitled to such a review. It behooves us to be as discreet as possible in making our notes in the record. On one occasion, a staff physician who was exasperated by the hypochondriacal nature of a student from Taiwan, recorded as a recommendation, "Rx: a slow boat to China."

In closing, there are many problems in the delivery of health care to a student group; however, in my experience the pleasures outweigh the pains!

DEGENERATIVE DISEASE AND INJURY OF THE BACK

Examination of the Lumbrosacral Spine

Lee T. Ford, MD

THE HISTORY

In evaluating a patient's lumbrosacral spine, the presence of symptoms, usually pain in the low back with or without associated symptoms in the lower extremities, is a key consideration. The manner in which such symptoms develop is also important. For medicolegal reasons it is wise to record the dates of any traumatic episodes and their time relationships with the development of symptoms from the alleged injury. The presence of preexisting symptoms is likewise important.

It is helpful to know how the symptoms are affected by rest or activity and whether coughing or sneezing aggravates them. A history of numbness, tingling, or weakness, the presence of a list and whether or not there has been any bladder or bowel involvement, are important to determine. Whether or not symptoms are helped by different modalities of treatment such as back supports, medications, or manipulative therapy may be useful.

THE EXAMINATION

In examining the lumbrosacral spine, the patient first should stand adequately exposed in front of the examiner, and then walk back and forth in the normal gait. In medicolegal cases it can be helpful to observe the gait without the patient's knowledge; perhaps walking in the waiting room or in the parking lot when the gait may be quite different than in the examining room.

With the patient standing, the examiner should observe whether the spine is straight and the pelvis is level. A large mirror in the examination room is very helpful. The examiner should look for a list or a scoliosis and have the patient walk on his toes and on his heels. Difficulty with, or inability to perform these movements can indicate paresis or, on the affected side, paralysis in the calf group or in the anterior muscle group of the leg. In sciatica, pain when performing either of these maneuvers helps to localize the level of neurological root involvement. Pain on toe walking may indicate first sacral root involvement, and pain on heel walking, L-5 root involvement.

The patient is then asked to assume a full squatting position, placing the head between the knees. If the patient can, this quickly indicates full flexion of both hips and both knees. The patient is then asked to arise from this position, and any difficulty is noted. With the patient standing, a jugular compression test is done to see if this causes either low back pain or sciatic pain, which may indicate a space occupying lesion in the spinal canal. The patient is then asked to bend the trunk in all directions. Each motion is observed. The lumbar lordotic curve should iron out into kyphosis on flexion. Pain, muscle spasm or arthritic fixation of the spine may limit this motion. Now is the time to observe the presence of any list, which is usually increased on forward bending. Restriction of bending motions is estimated as slight, moderate or severe, rather than in degrees. It may be helpful to measure forward bending as the distance the patient can approximate his hands to the floor.

The patient is asked to report any subjective symptoms with the back motions and to locate, or point to the site of, pain. Lateral bending to each side is carried out in the same manner. A patient with a list and muscle spasm usually has full motions to the side of the list and no motion or restricted motion away from the list. It is important to watch for the rare case of camptocormia, which is a functional or hysterical inability to stand erect, although in bed or on the examining table the patient can extend his hips fully. Backward bending is checked in the same manner. Any restriction or symptoms with it are being noted.

The patient is now asked to sit on the side of the examining table or bed. Knee jerks are checked very carefully, comparing one with the other. Reinforcement of the knee jerk may be obtained with light contracture of the quadriceps against the examiner's finger. Locking the fingers of each hand and pulling may help the reinforcement. Ankle jerks also are checked in the sitting position. They also may be reinforced by having the patient very gently plantar flex the foot against the examiner's finger and by pulling the fingers against each other.

The patient is now instructed to lie supine on the bed or table. Leg length is measured from the anterior superior spine to the medial malleolus. It has been my experience that this measurement is accurate only about two times out of three. Measurement with a standing AP x-ray of the pelvis is considerably more accurate, if properly performed. Circumferences of the thighs and the calves are carefully measured for asymmetry, which is evidence of possible muscle atrophy. Strength of the toe extensors is carefully tested--for weakness of the extensor hallucis longus is pathognomonic of involvement of the fifth lumbar nerve root.

Sensation is carefully tested in both lower limbs by light touch and by the use of a pinwheel. The most common sensory finding is a functional or stocking type of hypesthesia in the lower limb. The pinwheel is quite useful in checking this: the wheel is always moved from the anesthetic or hypesthetic portion to the sensitive portion, beginning with the toes. Usually the patient jumps, effectively indicating the point of sensory change. Should the sensory loss be dermatomal, this is outlined.

The range of motion of the hips and knees is checked, especially rotation of the hips, lack of which would be evidence of hip pathology. While this is being done, the examiner holds the knee in one hand and the leg in the other, feeling for presence of crepitus on flexion and extension and checking the stability of the medial and lateral ligaments.

Straight leg raising is now tested, with the knee extended and the leg raised upward from the hip. This is a subjective test, and the patient's response to it must be evaluated. The production of pain, either in the low back or gluteal region, is a positive test. The approximate angle at which pain is produced is noted. A stretching sensation behind the knee is normal at ninety degrees. The test may be supplemented by flexing the hip and then extending the knee, and a positive test may be confirmed by also dorsiflexing the foot. Pain in the back produced by flexion of the hip with the knee flexed is called a positive bent leg raising test, and pain produced by it is usually on a functional or psychogenic basis. The straight leg raising test may be positive from 5° to 90°.

The patient is then turned in the prone position, with a pillow under the abdomen to flatten the lumbar spine. The calves, popliteal region, posterior thighs, buttocks, sacrum, coccyx, and lumbar spine all are palpated, and tender areas are noted. The examiner should be able to locate the lumbrosacral space on palpation and palpate firmly with the thumb the separate interspaces, locating any sensitive ones. The presence of muscle spasm in the lumbar musculature can be detected with a light tap by the percussion hammer while holding a finger on the muscle. Except for the presence of a list with palpable muscle spasm, this is the best ~~objective test I know to detect muscle spasm.~~

After complete physical examination of the lumbosacral spine, the next step in evaluation of the lumbosacral spine is radiographic.

DEGENERATIVE DISEASE AND INJURY OF THE BACK

Conservative Treatment of Low Back Conditions

Lee T. Ford, MD

The majority of low back conditions seen by orthopaedic surgeons are treated conservatively. Following the teaching of Dr. J. Albert Key, the author's opinion is that most persisting low back pain with or without sciatica is due to some type of lesion of a lumbar disc. Even patients with disabling symptoms from lumbar disc lesions, with rare exceptions, should be given at least three to six weeks conservative treatment before a decision about surgery is made. One exception to this would be a patient with serious neurological deficit with paresis or paralysis in the lower limb, or where there is involvement of bladder or bowel control, when even emergency surgery may be indicated.

The author also believes that for an intervertebral disc to rupture, there must be pre-existing changes of degeneration in the disc. A normal nucleus pulposus surrounded by a normal annulus fibrosis should not herniate. For such to happen, trauma would have to be so severe that a vertebral body would fracture before the disc would rupture. The usual muscular sprain or wrenching injury of the low back causes symptomatology which should clear with conservative management of several weeks or more.

Conservative treatment of patients with low back pain, with or without sciatica, begins with rest with one or more of several measures. The patient will usually do this voluntarily by limiting his activities, perhaps with lighter work or by taking time off. A common method of resting the back is to splint it with a lumbosacral back support. This should be of a type that takes the lumbar spine out of lordosis and tries to hold it flattened with the abdomen compressed. The lordotic position will increase the bulge of an intervertebral disc while straightening the lower spine tends to flatten the disc. Heat with warm soaks or showers may help. Local heat with a heating pad or hydrocollator is useful. The patient should use a fracture board under his mattress, which may be firm or soft.

Resting in the so-called "contour chair position" is usually helpful. This may be done at home with pillows or with a lawn chair or TV chair. Symptomatic medications are used. Narcotics are avoided as much as possible, but some patients may require something like propoxyphene hydrochloride ("Darvon") or codeine. Muscle relaxants are commonly prescribed, but how effective they are I am not sure. The more tense or anxious individual may be helped by a tranquilizer. If leg length discrepancy of 1/4 inch or more is present, a heel lift should be prescribed to level the pelvis.

Physical therapy modalities of local heat, massage, diathermy, and ultrasound, or whirlpool baths, may help the patient. For the patient with more severe disabling symptoms, hospital management should be considered. This would consist of bed rest with the back rest and knee rest elevated, and leg traction or pelvic traction may be used. These only help immobilize the patient in bed and do not "replace" anything. Patients with clinical evidence of lumbar disc lesions may be helped by manipulative therapy. In my hands, this is most effective using general anesthesia. This can improve symptoms, sometimes dramatically, in over one-half of persons manipulated.

Associated medical problems should be evaluated properly and treated. Accompanying functional overlay, particular in the medicolegal cases, may be difficult to evaluate. Consultation with a neurologist or a neuropsychiatrist may be indicated to help evaluate the patient's symptoms and plan treatment. In difficult cases of low back pain with or without sciatica, we occasionally use a quantitative spinal examination as described by McCollum and Stephen (1). This can help distinguish the organic case from the patient with purely functional or psychogenic origin of complaint, or can indicate the patient with pain on an autonomic basis. In rare cases, to evaluate the percentage of organic versus functional or hysterical symptomatology, we may have a neuropsychiatrist examine the patient under amobarbital (2).

One observation is that in medicolegal cases, the greater the amount of possible gain, the greater is the percentage of functional or psychogenic overlay. This is seen fairly often in compensation cases, but more frequently and to a more severe degree in those cases that may be tried in federal courts with much larger awards than under workers' compensation. This is noted particularly with workers involved in interstate commerce, whose cases are eventually tried in Federal courts.

For the patient who still has marked disability and has not responded to conservative measures, surgery may need to be considered. But before surgery on the low back is performed in such cases, a myelogram, in my opinion, is indicated.

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DEGENERATIVE DISEASE AND INJURY OF THE BACK

The Role of Myelography and Discography in Low Back Pain

Lee T. Ford, MD

The purpose of a lumbar myelogram in evaluating low back pain is to indicate the presence of a space-occupying lesion in the spinal canal, which may affect the dural sac. The most common abnormality seen in large series of lumbar myelograms is that caused by a disc lesion. In a review of 856 patients, all of whom had lumbar spine surgery, Dr. Edward Lansche and I found a neoplasm present in only 1% (1). These were patients with disabling low back pain and sciatica who came to surgery at three St. Louis hospitals.

Pantopaque is the most commonly used medium for such myelographic studies. In rare cases air has been used, but it is not as satisfactory as Pantopaque. Pantopaque is not readily absorbed, and we have used it without reaction on some patients who are allergic to iodine. In the same allergic patients one would not use an absorbable medium for intravenous pyelography or arteriography.

It is my firm belief that a myelogram should rarely be done merely to make or exclude the diagnosis of a ruptured lumbar disc. The procedure should only be considered after conservative measures have been tried adequately and have failed, and surgery is being contemplated. It is a procedure which will help determine the diagnosis of pathology in the lumbar spine, locate its level and serve as a guide to the surgeon, who will then explore the back as indicated.

Myelography is not 100% accurate. Properly performed, it is presently 90-95% accurate. Twelve or more cubic centimeters (12 cc) of the dye should be used. There should be enough dye that with the patient in the standing position, the level of the medium will reach the body of the fourth lumbar vertebra. The majority of disc lesions occur at the lumbosacral and at the penultimate disc. Even with well performed myelograms, false positives and false negatives may occur.

During recent years we have had favorable experience with Dimeray (Dimer-X) involving several hundred patients at the Mallinckrodt Institute of Radiology and Missouri Pacific Hospital. This is an absorbable medium which fills root sleeves farther out than does Pantopaque and is not as dense. The material requires four to six hours to absorb, and the patients must be kept in an upright position during this time. If the medium is allowed to contact the spinal cord or brain, muscle spasms and epileptic seizures may occur. The drug was withdrawn from use in the United States several months ago after three fatalities occurred shortly after radiculograms with Dimeray. The medium is still in use in many other countries.

A lumbar myelogram is normally done with local anesthesia and is performed with careful sterile technique. In rare cases, a patient may be in so much pain as to be unable to lie in the prone position. In such a case, a general anesthetic with intubation has been used, although sometimes relaxation with intravenous diazepam (Valium) has allowed the myelogram to be completed without general anesthesia. Demerol should not be used as a pre-medication for a myelogram, because a sizeable percent of patients may become faint, sweaty and hypotensive. The best pre-medication is a barbiturate with atropine.

Technique in performing a myelogram is quite important. We follow that recommended by Shapiro in his excellent book on myelography (2). A lumbar interspace should be selected above the site of suspected pathology. The needle puncture site is usually at the second or third lumbar vertebra. Midline insertion of the needle is essential and is best performed with x-ray control. For this reason, the procedure is done with the patient in the prone position with two pillows under the abdomen to flatten the lumbar spine. A clear flow of spinal fluid is essential. Adequate fluid is removed for testing. If there is some blood in the first few drops and the fluid clears, one may procede with the myelogram. Determination of spinal fluid pressure is optional. If a bloody tap is obtained and does not clear and Pantopaque is injected, there is a good chance of producing an arachnoiditis. Experimental studies in dogs have shown, that Pantopaque mixed with the dog's own blood injected into the subarachnoid space produces an intense arachnoiditis (3). Should such a bloody tap be encountered, the Pantopaque study should be delayed two to three weeks to allow the blood to absorb.

After Pantopaque is introduced, adequate fluoroscopic studies with films are essential and should extend from the cul-de-sac to the lower dorsal spine. The reason for this is that in about 1% of patients with low back pain and aciatica, a disc lesion can exist in the lower dorsal spine. Rarely, tumor may involve the lower cord and affect the same roots as disc lesions in the lower lumbar spine. Thus, a Pantopaque study is not complete unless the lower dorsal spine is included. It is essential that fluoroscopy and films in all four planes be made (anteroposterior (AP), lateral, and both obliques), also including those views with the patient in the upright position.

Several types of defects in the dural sac may be encountered. The common one from a disc rupture is indentation. If this is on one side only, a prone or cross-table lateral view may result in what is called a "double density." Root sleeve asymmetry may be the only abnormality seen, or there can be a complete block of the column at any level. It is important to study the outline of such a block in all planes, to determine its location in relation to the level of the disc and its outline as to whether it may be from a disc lesion or a neoplasm. Enlargement of nerve roots intradurally can result in striations of the dye column, which is said to be the result of retrograde edema of the roots compressed distally. Tumor defects must be watched for. Gross striation, irregularity, and even blocks, may be associated with arachnoiditis.

Upon completion of fluoroscopy and films, removal of as much Pantopaque as possible is done. The use of a newly devised Quatico needle is quite helpful. Its stylet has seven small perforations so that suction of intradural roots against several perforations will still allow oil to be extracted through the others. The end of the stylet is round and once inside will not penetrate the dural sac. If a standard spinal needle is used, an eighteen gauge size is needed, and it is important during oil extraction to keep the bevel caudad or cephalad at all times, so that roots are not sucked against the bevel. Again, central placement of the needle is essential, since the dural sac narrows laterally and is widest in the midline.

DISCOGRAPHY

This author, over a nine year period, had the experience of performing discography in the majority of over 850 patients on whom he used chymopapain for chemonucleolysis for lumbar and dorsal disc lesions. Ninety-five percent of these patients had myelography performed and the same percentage had discography performed. This gave an opportunity to study the efficacy and diagnostic accuracy of the two procedures.

The absorbable media used were: Diodrast, Renograffin and Conray. A discogram shows different factors than a myelogram. It will define a normal nucleus pulposus. It will indicate degeneration, a very common finding. When a disc begins to degenerate, the nucleus enlarges at the expense of the annulus, which becomes thin and weakens. A grossly degenerated disc can have dye injected into the nucleus through the annulus with a needle at almost any part of the disc. For a discogram to demonstrate a normal nucleus, the needle tip must be within the pedicles in the AP x-ray and close to the midline in the lateral projection.

A discogram may show a bulging disc, a protruded disc with a thin annular ligament, or a possible extrusion of disc material by dye leaking into the spinal canal. If the discogram injection is done under local anesthesia, injection of dye at the offending disc should reproduce the patient's pain in the back and disc. The fact that a discogram reveals degeneration does not mean that disc is necessarily the offending one. The same is true in lumbar myelography. There are several series of cervical myelograms which showed asymptomatic disc ruptures in the lumbar area.

The discogram may be most valuable when it shows a normal nuclear outline and so may avoid an unnecessary exploratory laminotomy.

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DEGENERATIVE DISEASE AND INJURY OF THE BACK

Biomechanics of Manual Materials Handling and Low-Back Pain

Don B. Chaffin, PhD

When a person lifts, pushes or pulls on an object, forces are produced that can act in an adverse fashion on the musculoskeletal system. These forces are normally sensed by the person and maintained within the "safe" mechanical limits of the tissues involved. Unfortunately, however certain conditions can exist that increase the forces above what the person expected and normally could tolerate, and the mechanical properties of the tissues can deteriorate to a greatly reduced level through prior strains, diseases, nutritional deficiencies, and so forth.

The results of such circumstances are presented in this paper. The industrial physician, by his training and traditional responsibilities, serves as a major contributor in protecting workers against the injury-producing physical stresses of the occupational environment. The newly emerging field of biomechanics can greatly assist the physician in understanding how specific forces operating on and within the body affect a person's health.

SCOPE OF CONCERN

The most general concern is, what can a person do physically that will not harm him? Reflection on that question often leads one to ask more basic questions regarding the person's health status and what physical task the person is being required to perform in a job. In the industrial setting, this means that the person's physical capabilities must be assessed along with the physical demands of a prospective job. In particular, one becomes most concerned with those physical attributes of the individual and job that have been found to produce either increased injury rates or severe injuries.

In past decades, there have been increasing attempts to understand how lifting, lowering, pushing and pulling loads adversely affect the status of the low back. This paper is oriented to these questions.

BIOMECHANICS OF MANUAL MATERIALS HANDLING

It is well established that stresses induced at the low back during manual materials handling are due to a combination of the weight involved and the person's method of handling the weight. Specifically, the load held in the hands and the person's body masses, when acted upon by gravity, create rotational moments or torques at the various articulations of the body. The skeletal muscles are positioned to exert forces at these articulations in such a manner that they counteract the torques due to the load and body weight.

From the mechanical stress standpoint, it is unfortunate that the muscles act through relatively small moment arms. This means that they can produce large motions with small degrees of shortening, but that any load operating on the body often produces exceedingly high muscle and joint forces. As an example, consider the major elbow joint flexor muscles, i.e., the brachialis and biceps brachii (Fig. 1). Simply holding a given load in the hands requires about 7 times greater muscle force due to the mechanical disadvantage of the muscles.

As a numerical example, consider a 20 kiloponds (where 1 kp = 1 kg of force) object to be lifted with both hands from the back of a shelf at a shoulder height (Fig. 2). In this case, several biomechanical factors are worth noting. First, the elbow is extended, which reduces the flexor muscle moment arm to about 25% of its former value (i.e., r_M now is about 1.2 cm for an average man). This means that the 10 kp acting on each hand requires about 292 kp of force in the elbow flexor muscles, which does not include the extra load imposed by the forearm and hand weights.

One might suggest that this muscle force may not be excessive, since muscles are stronger when contracting. This is an important factor and does mean that the muscles may be capable of producing high forces, but what about the bones, joint cartilage and joint connective tissues? For instance, when muscles pull across an extended joint, they compress the joint with about the same magnitude of force. This coupling of muscle and bone compression forces is an important concept when considering low back biomechanics. In addition, high muscle forces inhibit blood flow, placing extra stress on the heart and leading to early muscle fatigue.

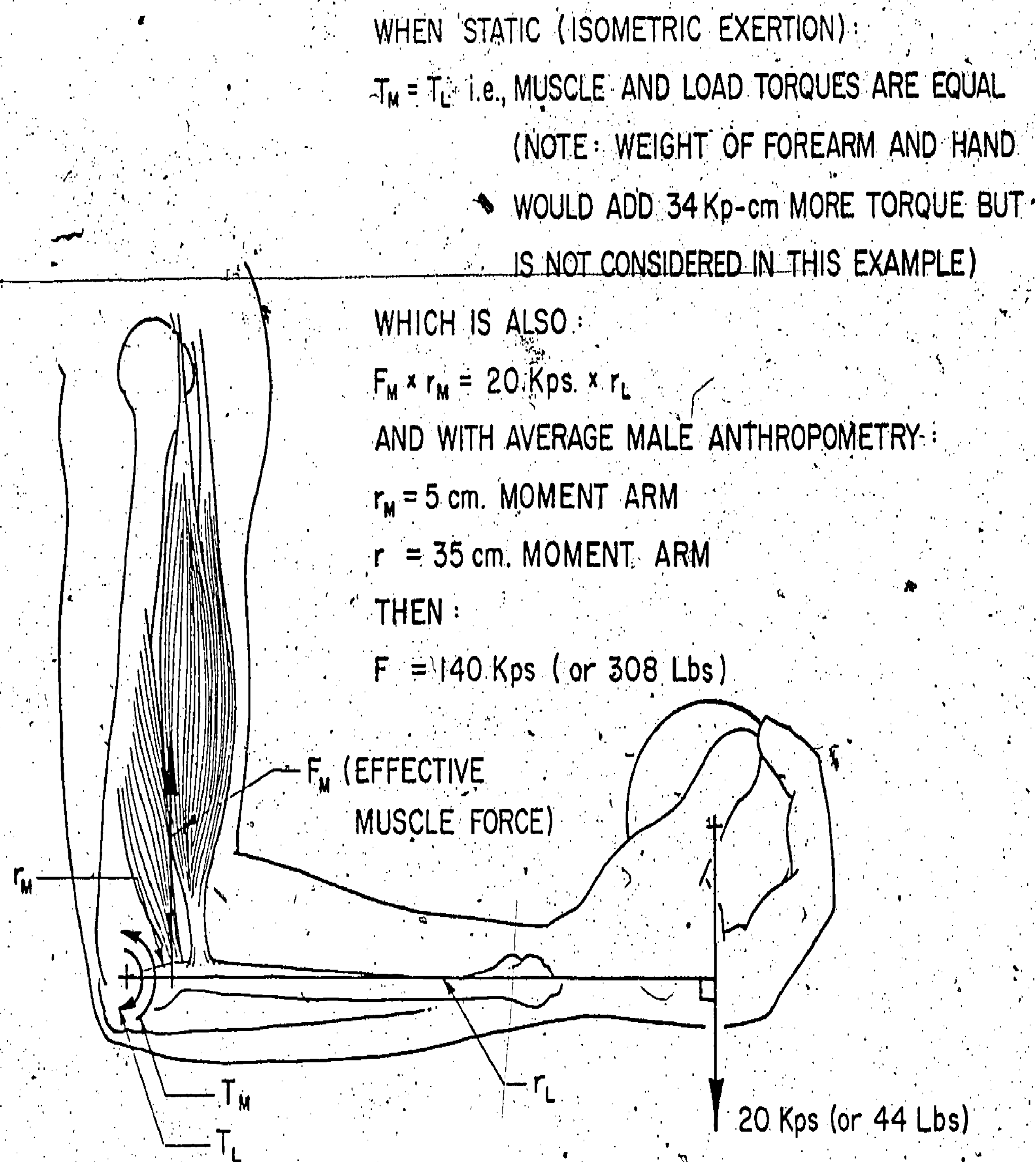

Figure 1: Example of how an external load creates high internal muscle forces

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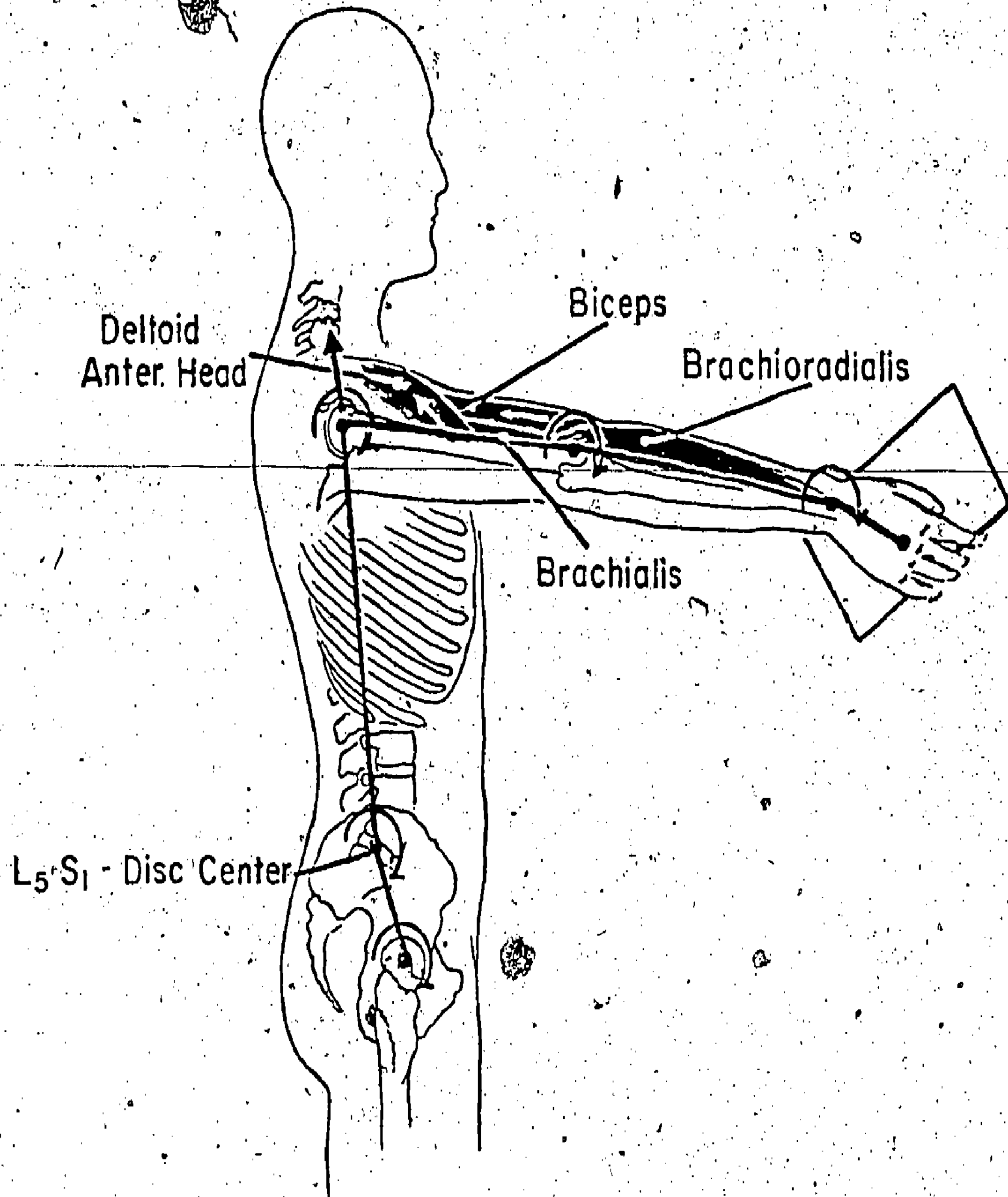


Figure 2: Illustration of how leverage operates on shoulder, elbow and lumbosacral joints

Another biomechanical factor is that shoulder torques, and therefore shoulder muscle flexor forces, are quite high due to the load acting through such a large moment arm (Fig. 2). The average male's arm length is about 63 cm to the center of grip. This means that the shoulder torque in the preceding example is about 630 kp-cm (i.e., 63 cm multiplied by 10 kp). If one includes the weight and distribution of the masses of the arm, this value becomes closer to 734 kp-cm, which empirical investigations have found to be more than what about 90% of the female population and about 40% of the male population can produce voluntarily in a similar posture (1,2). The major point, then, is that the shoulder joint is not well suited to withstand high forces when flexed or, as discussed by Tichauer (3), when abducted.

One might think that such lifting requirements do not exist in industry today. Unfortunately, this is not true. The layout of many machines, materials handling equipment and storage devices often compels the operator to assume biomechanically awkward and potentially injurious postures. Because the required posture has caused the worker to be straining himself close to his expected arm and shoulder strengths, any sudden slip of the object could cause an overstrain injury, or the object might fall onto the worker's foot.

A final aspect of note is that when a 20-kp load is held at arm's length, it also produces a high torque at the lumbrosacral joint. If an average man's anthropometry is considered, such a load produces more than 1200 kp-cm of torque, which, in combination with the torso weight, produces a compression force at the L5-S1 disk that is equivalent to what holding about a 40-kp load between the knees would produce. In other words, one does not have to "bend over" to produce high forces on the low back structures. A person with strong arms and shoulders can position his body in ways that greatly multiply an external load's effect on the low back, with biomechanical consequences to the low back.

The lumbar spine can be thought of as a set of small links with flexible articulations. With proper geometric and physiologic data, the torques in each disk during a specific lifting activity can be predicted. Because the clinical and biomechanical data indicate the greatest problem to be at the lower lumbar spine, the L5-S1 disk has been used to represent the spinal stresses of lifting in earlier studies by Morris, et al., (4) Tichauer (5) and Chaffin (6). These models have shown clearly that during weight lifting, the bending moment at the lumbosacral joint can become large, as high as 2000 kp-cm when lifting about 50 kp from the floor. To conteract this torque, the muscles of the low back region, primarily the erector spinae group, must exert correspondingly high forces, since they operate on small moment arms, about 3.8 - 5.0 cm, as referenced in an earlier work (7) and shown in Figure 4.

The high forces generated by the low back muscles are the primary source of compression forces on the lumbosacral disk. These concepts are illustrated in Figure 5 for a person holding a variable load, designated F_H in the diagram. The graph at the bottom of Figure 5 displays the predicted compression forces at the L5-S1 disk for increasing loads held in the position depicted, using a 50 percentile man's anthropometric data and normative abdominal assistance values (6).

The important concept in Figure 5 is that even in the "reasonable" lifting posture depicted, high compression forces are created in the disk. Direct transducer measurements of the compression forces in the lumbar disks (8) have confirmed the range of these predicted values.

The maximal amount of compression that can be tolerated by the lumbar spinal column has been estimated from axial loading compression tests on cadaver columns. Data from separate studies of this type (9,10) disclose large biologic variations in the disk and its weight-bearing cartilage end-plates. In general, the data concerning lumbar columns from males under 40 years of age disclose a mean of about 725 kp before the cartilage end-plates begin to exhibit microfractures. The fracture levels range, however, from as low as 300 kp to more than 869 kp. Sonoda (10) estimates that the female's spinal compression tolerance is about 17% less than that of the male's. This is congruent with the smaller force-bearing area of the vertebral bodies in a woman's spine.

Two observations are worth noting from these types of cadaver studies. First, the disks themselves, if healthy, do not herniate. Instead, the cartilage end-plates that distribute the compression loads to the bodies of the vertebral segments fail (11). Second, the large

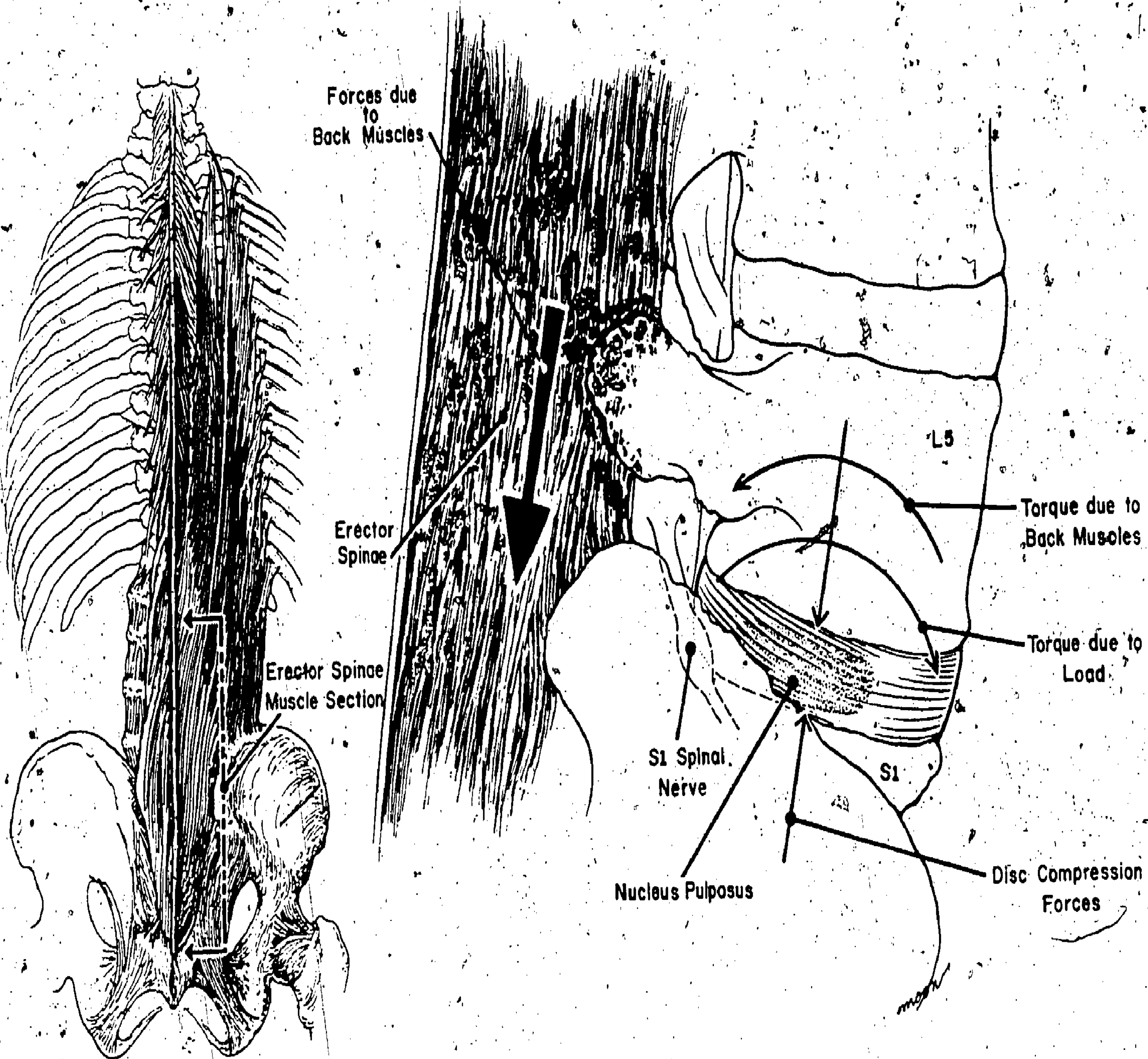


Fig. 4. Forces and torques operating during load lifting

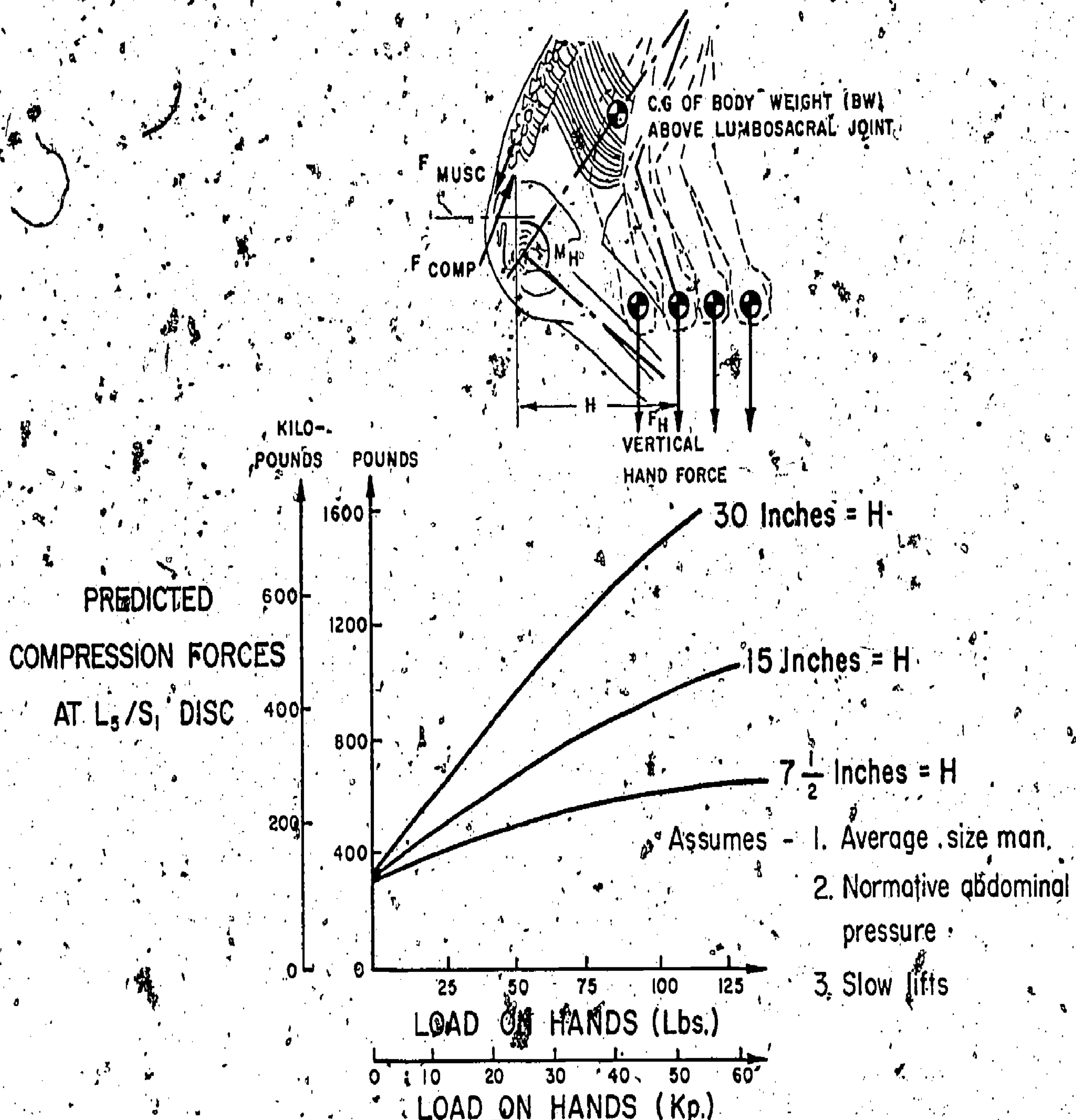


Figure 5: Predicted compression forces acting on L5/S1 disk when lifting loads of various magnitudes.

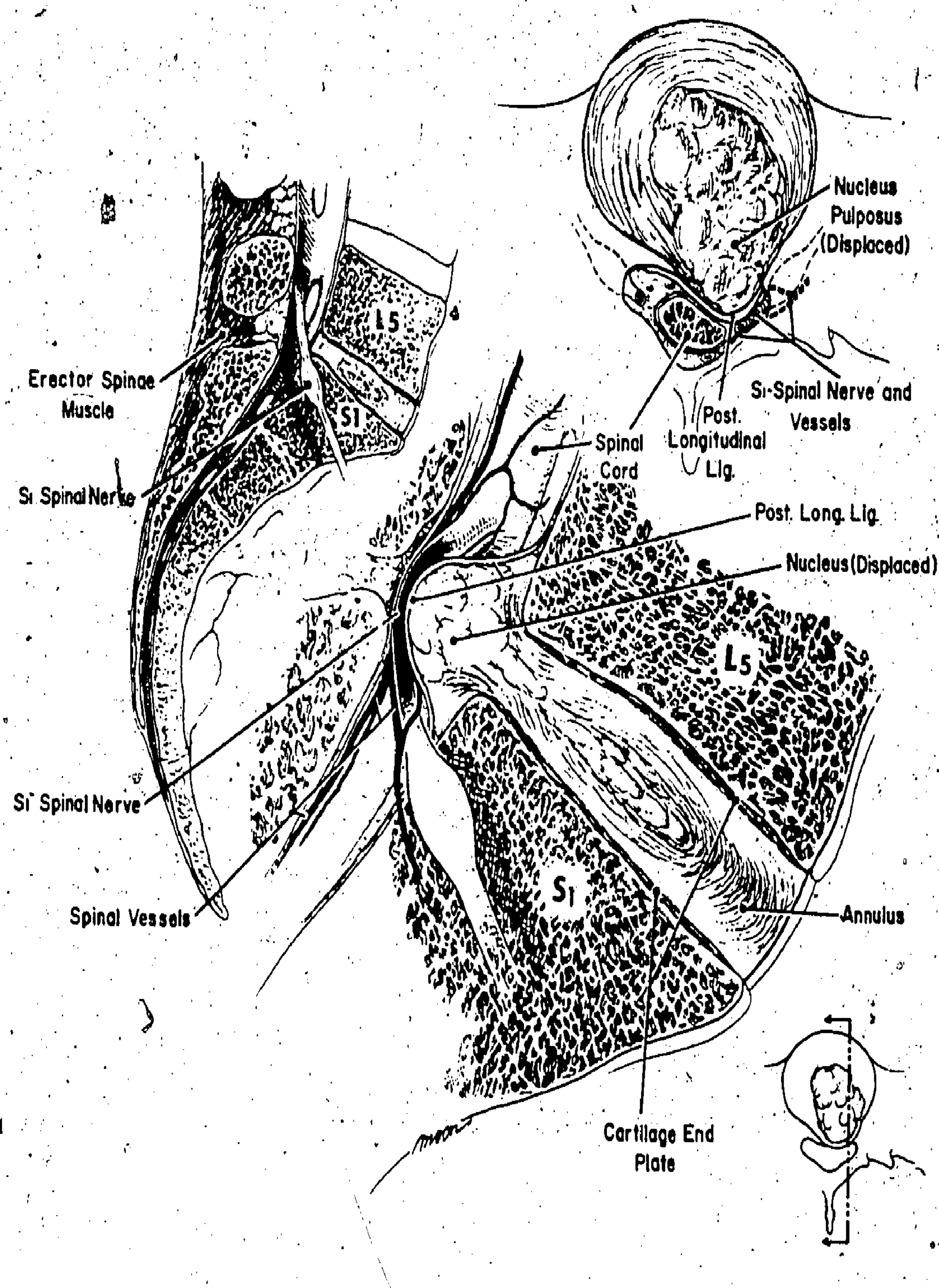


Fig. 6. Displaced degenerated disk exerting pressure on spinal nerves

variation in strength of the cadaver columns may indicate that the cartilage end-plates of some people already have been weakened by prior stresses, with resulting micro-fractures and scarring. If true, this could also contribute to the disk degeneration that now is acknowledged as being necessary before the more common and most serious diskogenic low back problems can develop.

Evidence indicates that repeated compressive stresses of life, lifting in particular, can be sufficient to cause microfractures in the cartilage end-plates and subchondral bone of the vertebral bodies, which then theoretically could alter the metabolism and fluid transfer to the disk. If this occurs, a decreased capability of the disks to withstand further compression loads would develop. The end result of this process is that the annulus fibrosus bulges or ruptures, causing pressure on the adjacent nerve roots (Fig. 6).

Some believe (12) 70-80% of all chronic low-back pain is diagnosed as discogenic after a period of repeated episodes. At the very least, degeneration and the narrowing of the disk that results contribute to a more unstable spinal structure. Some evidence that disk degeneration is accelerated by physical stresses has been developed by Hult (13). He reported that narrowing and osteophyte development of the disks and adjacent vertebral bodies was 1 1/2 times greater in those people engaged in heavy physical labor than in sedentary workers.

The implications of this disk degeneration theory are far-reaching. Most important is that assigning causes of low-back pain must not be based only on the immediate circumstances at the time when the pain first develops. In fact, most low back episodes do not suddenly start with a "jabbing pain," although these cases are easily remembered and reported by patients and physicians alike. Rather, the symptoms more often are slow to develop, with stiffness, dull aching pain and, finally, incapacitating discomfort, which may occur hours or even days later. With this in mind, it is easy to understand why the statistics relating a person's physical activities and the incidence of low-back pain are so poor.

Returning to the biomechanical aspects of manual materials handling, several general concepts may need further definition. First, there remains the issue of how a person's posture affects the low back stresses. It already has been shown that if the load is horizontally distant from the torso, large forces can result, even without bending over. Therefore, the first rule in materials handling is to ensure that the person is able to bring the torso as close to the load center of gravity as possible before lifting it. This often translates to having the person squat down beside the load with the legs straddling it when the load is on or near the floor, and lifting between the knees. This assumes, of course, that the load is small enough to go between the flexed legs easily.

If the load is small, the companion rule, keeping the back near vertical, is biomechanically justified, because this reduces the stresses due to torso weight. Unfortunately, lifting with the legs from a squatting position with the back vertical often is not possible, because the person does not have the quadriceps strength necessary to extend the knees and raise the body from such a position. In other words, most people when lifting weights lean their torso forward, thus reducing the torque on the knees. This is so common in lifting that the quadriceps muscles often are insufficiently developed to allow the person to "lift with the legs."

Thus, the rule about "lifting with the legs while keeping the back vertical" must be qualified to include the physiologic fact that many people will not be able to perform such lifting without first building up their leg strengths. In addition, muscle-stretching exercises will be needed for some persons to provide the necessary range of motion in the knees, hips, and ankles.

A second, more complex qualification on the classic lifting rule pertains when lifting larger objects that cannot pass between the knees. A recent study disclosed that when a large object is lifted in front of the knees, with the squatting type of leg lift just described, it necessarily causes the moment arm of the load about the low back to be large (14). This causes the torque at the low back to be large and, hence, high spinal compressive forces and muscle forces result. In contrast, the more often used stooped-back method of lifting allows the person to "move over" the weight to be lifted and thus reduce the load moment arm about the lower back.

Figure 7 illustrates this concept. For the calculation of the forces in the example, a 13.6-kp (30-lb) load is being lifted from a posi-

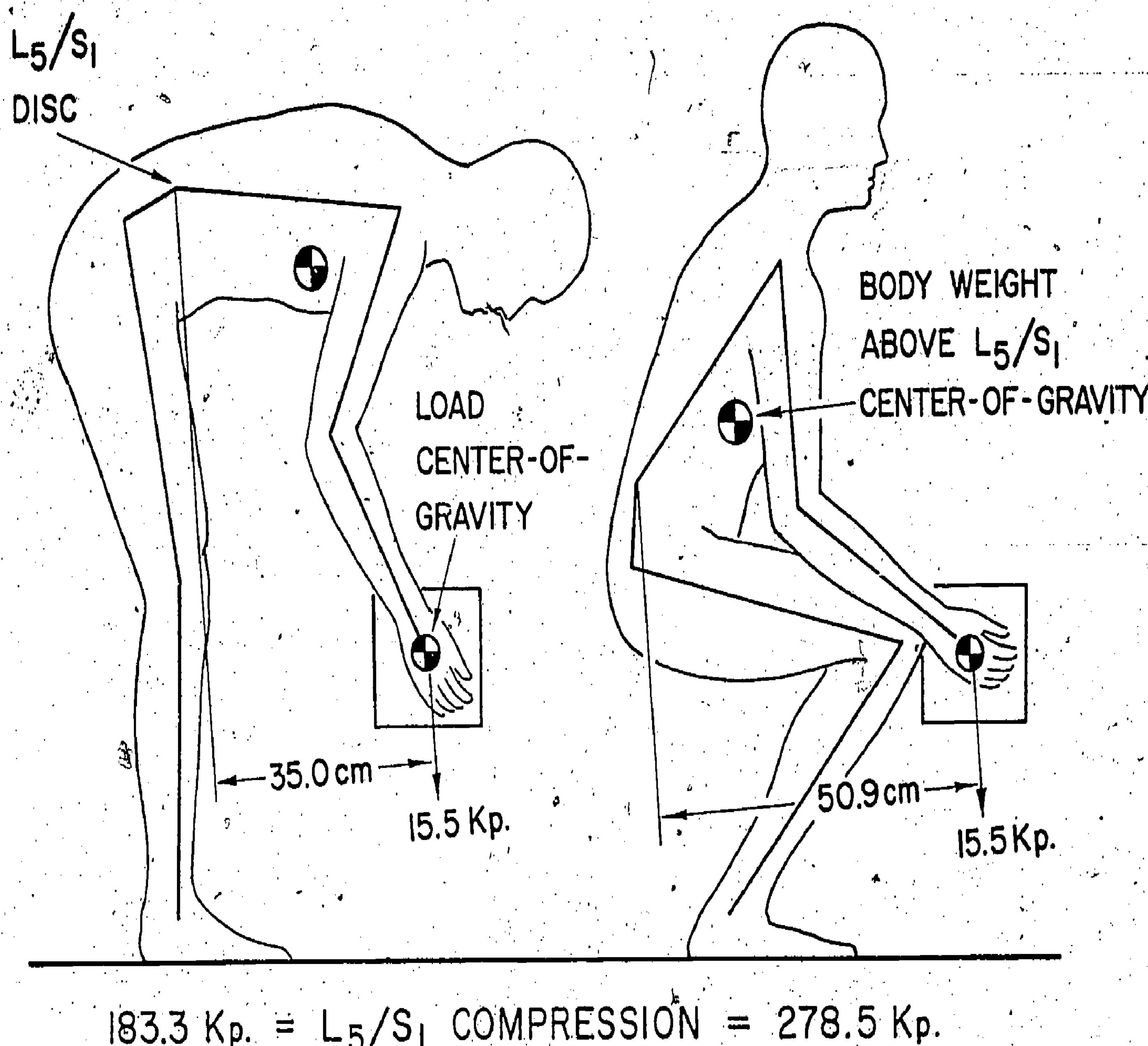


Figure 7: Low-back compression associated with two different lifting postures (load placed 38 cm from the ankle and 38 cm from the floor) with an assumed static load of 13.6 kp (30 lb)

tion that is 38 cm in front of the ankles and 38 cm above the floor. Nominal anthropometry and abdominal assistance values are assumed (15). It can be seen that the "stooped-over" position results in about one-third less compressive stress on the low back than the squatting type of lift. It should also be evident that the stooped-over position allows the person to reduce the load moment arm of 35 cm even further by moving in over the load more than is shown, whereas the load moment arm of 50.9 cm for the squat lift is as small as possible due to interference of the upper legs and the load.

A further limitation on lifting large objects with a squat lift arises from the fact that the arms must be extended farther in a more horizontal direction than with the stooped-over posture. As discussed earlier, such a position of the arms means that a high torque will be produced at the shoulders, which may not have the strength to move the load upward. Therefore, the person normally will lean forward more to lessen the load moment arm about the shoulders, and in so doing will cause greater stresses on the low back, both by the effects of gravity's acting on the torso mass and by hyperflexing the lumbar column.

Hyperflexion places a greater stress on the posterior portions of the annulus of the disk, thus distributing the compressive loads unevenly within the disk. This has led to the suggestion that lifting postures avoid a hyperflexed back. I agree with the suggestion that hyperflexion of the torso is contraindicated when lifting. As Troup (16) described, moderate flexion of the torso provides a more effective abdominal pressure assistance during lifting, thus reducing the low back stresses. Therefore, some torso flexion appears acceptable, but extreme flexion could predispose the lower back to injury when the peak load occurs at the beginning of the lift.

Therefore, based on simple biomechanical concepts, instructions about lifting postures must reflect concern for the person's strength and mobility as well as the size of the object to be lifted. Lifting of objects that cannot pass between the legs should be done with the more traditional stooped-over torso and legs only slightly flexed. Where possible, however, loads should be reduced in size to allow them to come between the legs. When this is possible, a squatting leg lift with the back nearly vertical is recommended.

The above recommendations are based on biomechanical considerations, but controlled field studies to determine their benefits have not been made. As others have stated (17,18) much more research is necessary to establish the validity of any suggested methods. Meanwhile, biomechanically based recommendations are worth consideration when counseling a person about lifting and carrying loads.

The preceding biomechanical discussion has considered relatively symmetric and slow lifting of loads. Symmetric lifting, wherein the load is held with both hands in front of the body, is by far the most common method of handling a heavy load, since it equalizes the stresses bilaterally on the musculoskeletal system. Sometimes ~~moderate loads are lifted asymmetrically.~~ Although the hazards of such lifting postures have not been documented in controlled field studies, biomechanically one must be concerned.

An asymmetric lift, which has the person bring the load up along the side of the body, causes a lateral bending moment on the lumbar column and also because of lordosis of the column, it produces a rotation of each vertebra on its adjacent vertebra. One laboratory study (19) indicates that disk degeneration most often involves the annulus fibrosus, which is the structure that provides 40-50% of the torsional resistance to twisting of the lumbar vertebrae. With disk degeneration, this torsional resistance can be reduced to less than one-half its normal strength, thus providing a significant magnitude to strain a specific muscle of the many required to stabilize the column.

In general, it must be concluded that lifting loads along the side of the body is to be avoided, for a person's arm and shoulder strengths are not well enough developed to lift heavy weights in an asymmetric fashion. Moderate load lifting, however, may be attempted using a side lift, and therefore instructions and job redesign often are indicated to reduce the stresses. Unfortunately, "safe" lifting levels have not been established for asymmetric materials handling. This is a major problem in occupational biomechanics.

Another limitation regarding present knowledge relates to the dynamics of load lifting. One investigation (14) disclosed that lifting a load between 6.5 kp and 23 kp from the floor to an erect carrying position, with the load against the thighs, resulted in an acceleration effect that added between 15% and 20% to static weight about 100 msec after beginning the lift. Furthermore, with fast motions the ability of the nervous system to coordinate the many muscles necessary to stabilize the spinal column is stressed. Electromyographic studies (20,21,22) have recently begun to identify the complexities involved in coordinating the recruitment of the back muscles.

It is hypothesized (17) that some low back problems are related to muscle fatigue, which further inhibits coordination of the back muscles. Tichauer (5) suggests that unanticipated motions while trying to catch falling or tossed objects cause low back injuries. Clearly, dynamic actions that result in high inertial forces are more difficult for one to control. Therefore, it is reasonable to suggest to people who are engaged in manual materials handling that they move loads in a slow and deliberate fashion. Good foot traction and hand grips on the load should be sought and provided at all times.

DATA RELATING LOW-BACK PAIN AND MANUAL MATERIALS HANDLING

The preceding section identified some of the salient biomechanical factors involved when a person is lifting and carrying loads, which must be considered when discussing hazards and risks of manual materials handling with supervisors and patients. From a more pragmatic standpoint, one must also seek evidence about the socio-economic dimensions of the problem, as well as about factors contributing to the problem. This section presents such data and causal factors.

The seriousness of low-back pain in the work force in the United States and elsewhere is well known. Estimates of the proportion of compensable medical claims that are low back in origin range from about 15% for all U.S. industry, based on National Safety Council statistics to 30% for certain industries in Sweden (13). Snook and Ciriello (23) report that the incidence rate appears to be increasing faster than the rates of other types of injuries. As an example, they cite the statistics for Wisconsin, wherein compensable back injuries increased from 8% of all claims in 1938 to 19% in 1965. It is estimated that 30 million workdays were lost in Great Britain due to low-back pain in 1968 (24). Hult (13) estimates that approximately 2 million workdays are lost in Sweden for similar reasons.

Lost time estimates are not available for the United States. One estimate based on statistics of the Department of Labor and Industries for Washington State was that more than one-half million days were lost in 1971 due to compensable back injuries.

To determine the severity of the problem I reviewed the number of days lost by each low back patient reporting to the Medical Department of a large electronics manufacturing firm, finding a mean of four days per case. The distribution, however, was heavily skewed, and the mode was closer to two days per case. About 10% of the cases were serious enough to warrant lost-time compensation.

The average time lost per patient due to the more serious compensable back problems has been reported by the Department of Labor and Industries in Washington State to average more than 125 days. Similarly, Rowe (25) reported the average time lost for all employees at Eastman Kodak due to low back complaints was second only to upper respiratory ailments.

It is well shown that the length of incapacitation due to low back problems is 3-4 times greater if the person is engaged in heavy labor (26). Whether this is due to the physician's reluctance to allow the person to return to heavy labor, or because heavy labor causes more extensive pathology, has not been determined.

A recent survey (17) of compensable low back incidents in Ontario disclosed the distribution shown in Figure 8. This indicates that once a case is referred for workers' compensation, it is serious and probably will result in more than 30 days of lost work, depending on the diagnosis at the time. Also, for every compensable low back case perhaps there are 10 or more nonserious cases with 2-4 days lost work that must be considered in the total problem.

The magnitude of the global medical problem is best illustrated by the following. Of 194 diagnostic groups classified by the Commission on Professional and Hospital Activities, diskogenic problems ranked as the 11th most important reason for days spent in hospitals in the United States, and ranked as the number one reason in 13 states (27).

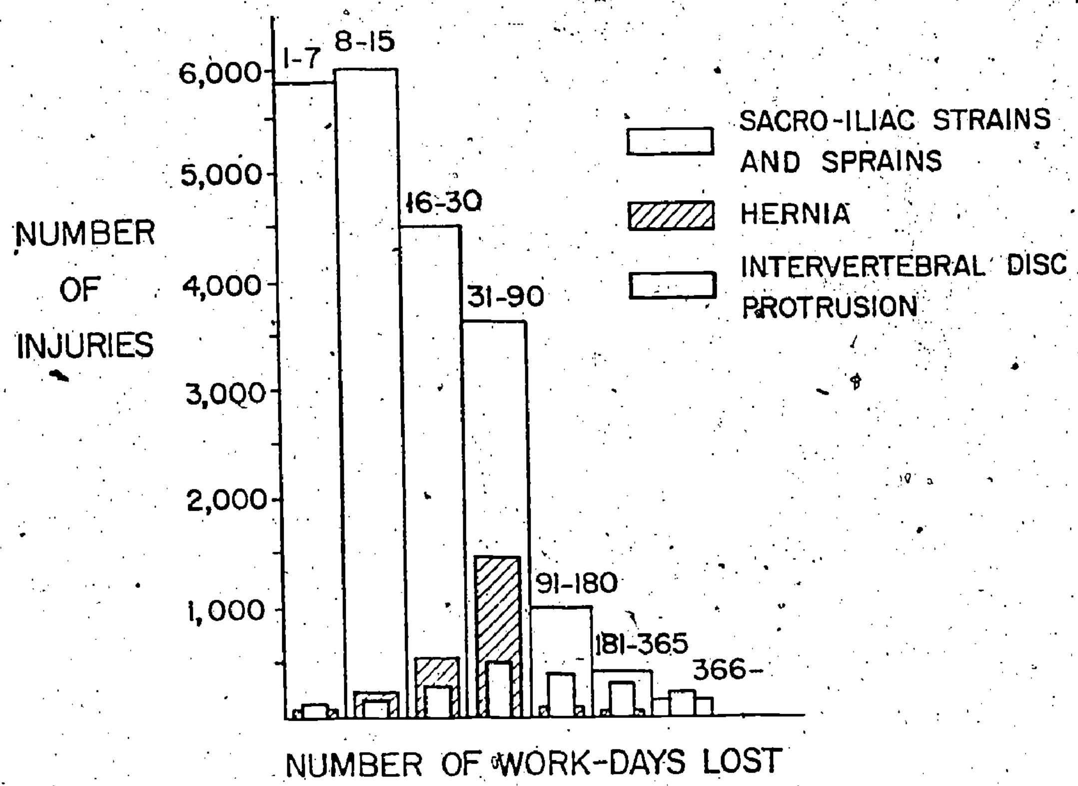


Figure 8: Frequency distribution of low-back injuries

Nachemson (28) estimates that 70-80% of the world's population suffers from disabling low back pain at some time in their lives. Furthermore, a majority of these episodes occur during the working ages, with the first medical episodes most often reported between the ages of 20 and 30 years (13,28,29). The age distribution of the more serious compensable cases (Fig. 9) was described recently by Brown (17).

Low back pain is recurrent in nature, with episodes occurring most often every 3 months to 3 years, according to Hult (13) and Rowe (25). Nachemson (28) believes that the frequency of repeated episodes peaks in the 40's. The fact that most low back patients do not demonstrate consistent symptoms with time led Rowe and Morris to conclude that diagnosis depends on following the progression of symptoms with time, 5 years often being required to establish a firm diagnosis. When such care is taken, Rowe and Morris believe that 70-80% of all recurrent or chronic low back cases will be diagnosed as discogenic (12).

It must be concluded that low-back pain is a major source of incapacitation, suffering and cost in the world. It tends to affect younger people and is episodic but is recurrent in nature, which makes causation very difficult to establish.

In fact, to refer to low-back pain as an "injury" is not doing justice to the complexity of the medical problem. In one review (30) only about 4% of the low back patients were classified as having "trauma-induced" symptoms, with a specific act associated with their onset.

Lack of a clear temporal relationship between physical act and symptom onset has made it difficult to acquire statistics which might confirm causation. Some have concluded neither retrospective studies nor cross-sectional studies clearly indicate the specific hazards associated with lifting activities (23). Perhaps much confusion in the results of past studies could have been avoided if the activities performed by people were described with reference to the biomechanical factors presented earlier. In past studies, jobs have been classified as heavy, medium or light work. With regard to low back stress a job classified as light or sedentary by traditional criteria, e.g. caloric cost of performing the job,

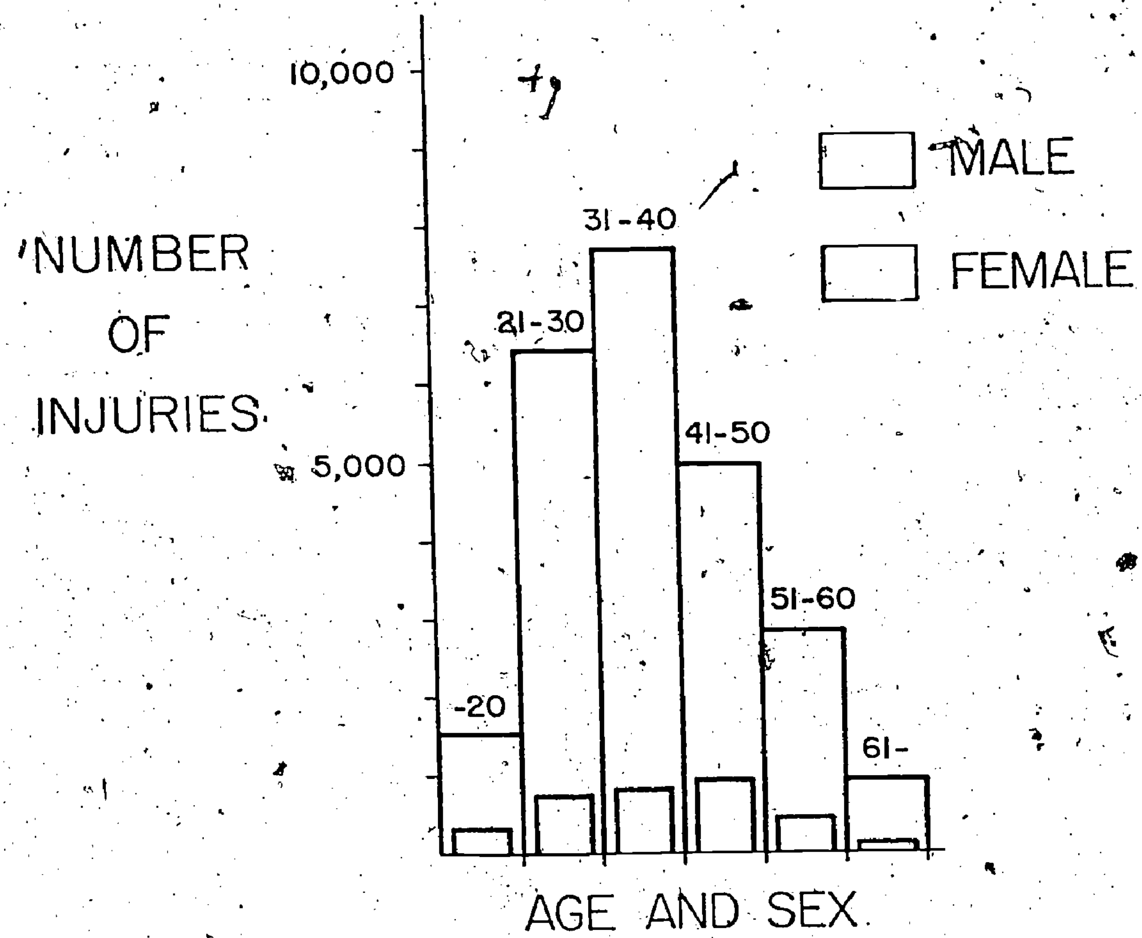


Figure 9: Age distribution of compensable low-back injuries.

may require the person to lift a 10- or 20-kp tote box a few times during a work shift. Depending on body posture, such infrequent lifting acts could produce injurious mechanical stresses on the low back.

Recently, longitudinal studies have been completed to circumvent the problems of incomplete data about on-job physical activity and the time lag between symptoms and job stresses. Two were conducted in eight different plants. Each plant had a full-time physician and an engineer trained in biomechanics to evaluate the jobs. The studies involved over 1,000 different jobs performed by 975 men and women. Visits to the medical departments were recorded over a 12- to 18-month period. A low back incident was a report of low back pain symptoms and signs that were initiated or aggravated by the person's job, and which required some form of treatment.

Physical stress evaluations of the jobs in the study were accomplished by the following procedures. First, the industrial engineering and job classification records were searched for jobs that had some amount of manual materials handling. These "candidate" jobs then were inspected by the biomechanics engineer, who assessed the various amounts of weight handled in the jobs, how far from the person's balance point (forward foot) each weight was located at both the beginning and the end of the lifting or carrying act, and the frequency of the acts. He then compared these data to a graph predicting the lifting capabilities of 97.5% of men in the working population (based on a graph considering models of workers' muscle strengths, body balance capability, preferred load-lifting postures and lumbar spinal column force capabilities (1,2,6).

The graph used in the evaluation (Fig. 10) assumes slow, well-controlled handling of tote boxes with both hands symmetrically in front of the body. Although it implies a simplification of the complexities of load handling, it provides a rating based on two important biomechanical stress factors: the weight handled and the position of the weight relative to the person.

By using the graph and depicting a large, strong individual's capabilities, the job analyst was able to normalize the job lifting strength data for all people. If any combination of the load magnitude and load location on the job approaches the values indicated in the graph, the job analyst knows that only a very strong

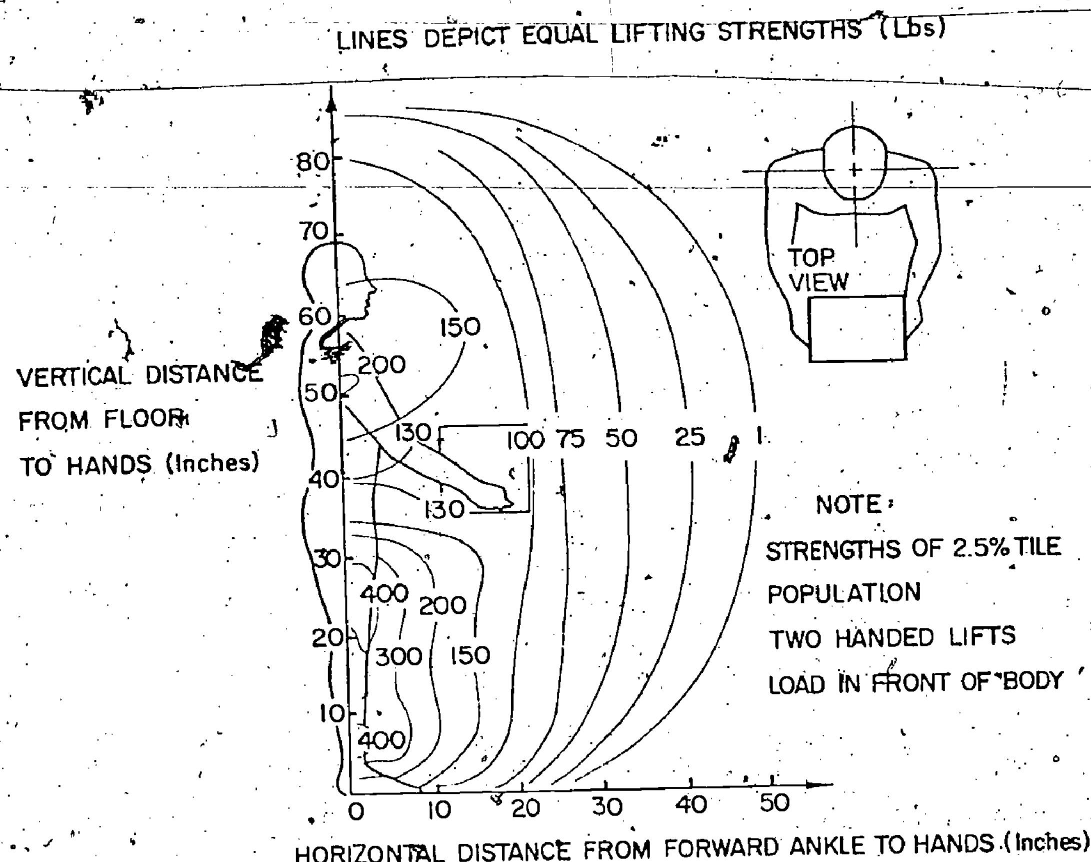


Figure 10: Predicted lifting strengths for all but 2.5% of workmen

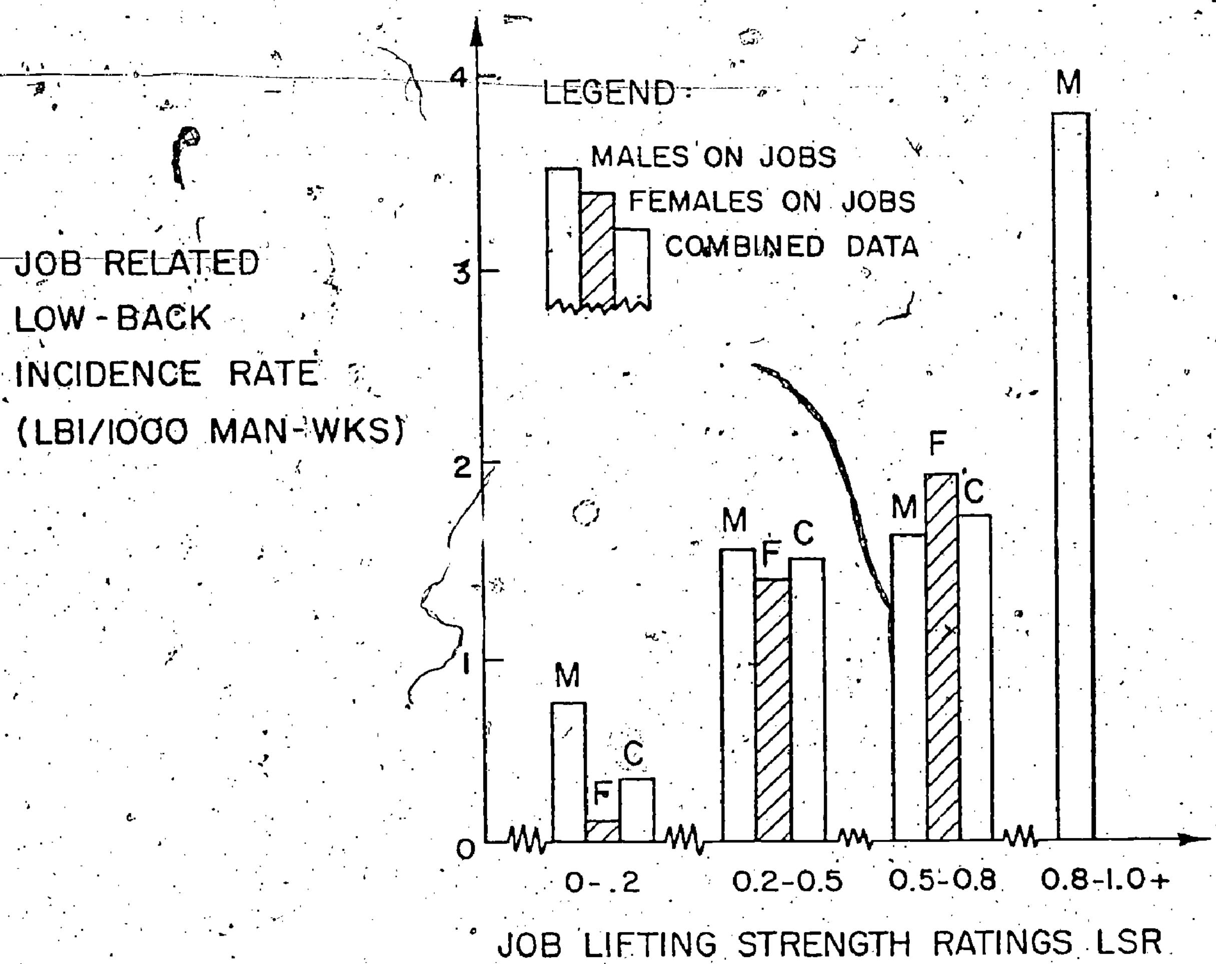


Figure 11: Mean low-back incidence rates for jobs having varying lifting strength requirements

and large person can handle the load. The Lifting Strength Rating (LSR) for each job then was developed; it is simply the largest value of the following:

$$\text{LSR} = \frac{\text{Each weight lifted in the job (kp)}}{\text{Predicted lifting strengths for large/strong man in job lifting positions}}$$

The value of LSR would go from zero, with little or no lifting required, to 1.0, with lifting such that only a very strong person could perform the job.

In these studies lifting strengths varied greatly, thus allowing a comparison of incidence and severity of low-back pain and other musculoskeletal disorders. Figure 11 describes the results of one of these studies, with the incidence rate of low-back pain being the dependent response variable (31). A strong positive trend is indicated as the LSR increases. In the moderate-strength-requiring job, where a potential hazard appears to exist, weight lifting is an equally serious hazard for both men and women. Males only were working above the LSR values of 0.8. It should be noted the female working on the moderate to heavy stress jobs ($0.2 > \text{LSR} > 0.8$) were, as a group, much stronger than their counterparts working on the low stress jobs.

When both on-the-job and off-the-job low back pain episodes were counted, the same trend in the data resulted (31). Thus, we concluded the lifting of loads greater than about 16 kp, about 35 pounds, when held in close to the body, or equivalent conditions, such as 9 kp between 50 and 75 cm in front of the body, could be potentially hazardous for some, as indicated by the increased injury incidence rates of the working population studies.

An impressive result is also presented (Fig. 12) when severity rates for both low back and musculoskeletal complaints are compared with the load handled requirements (32). It is evident that as the maximum load lifted on the job increases, the injury severity in terms of days lost and medical restrictions increases. In general, load handling of less than about 22 kp (50 pounds) was associated with few severe incidents of a strain or sprain diagnosis, but the

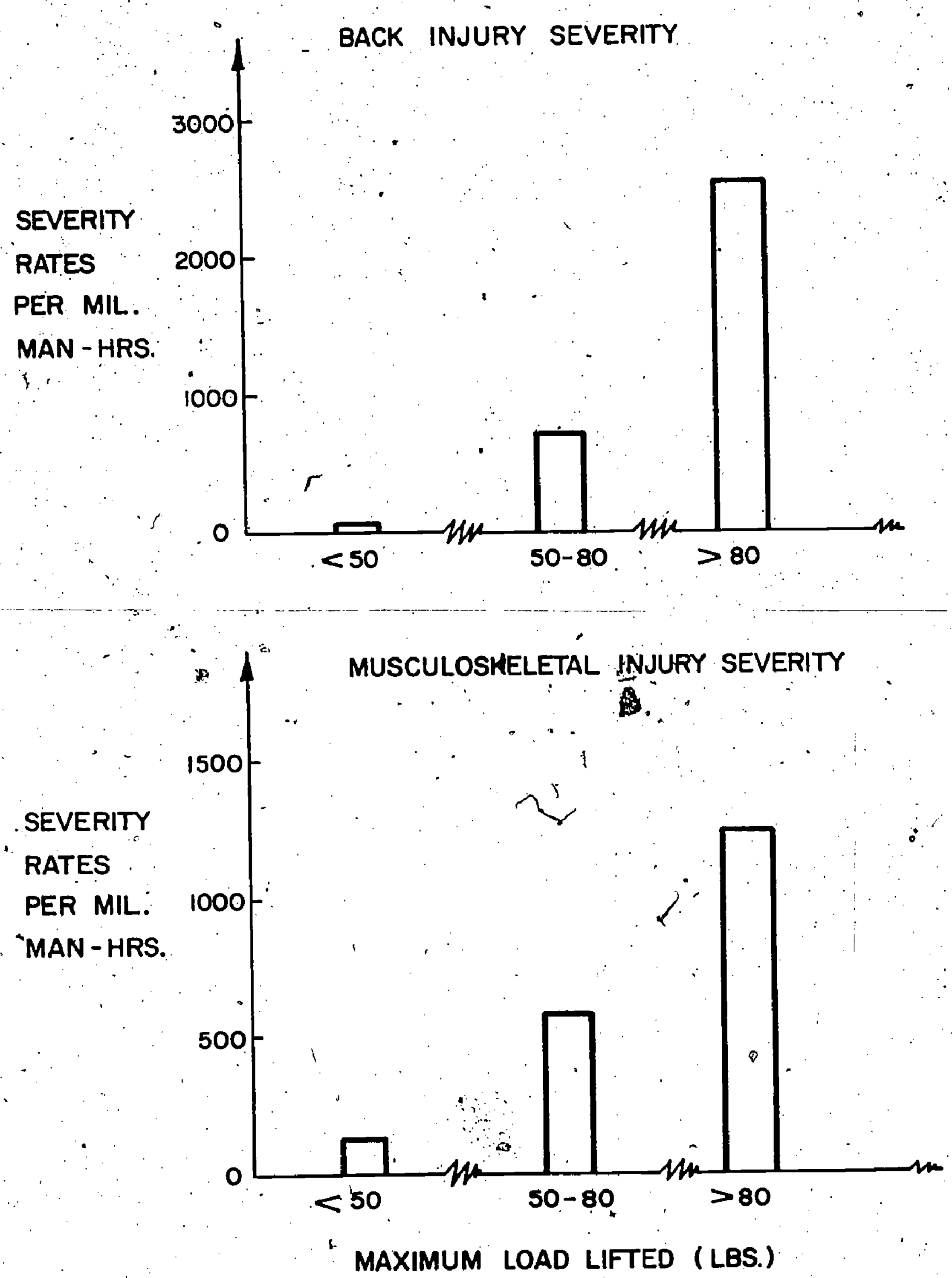


Fig. 12. Severity rates of back and other musculoskeletal injuries for various maximum loads lifted on jobs.

heavier load handling jobs were associated with many severe sprains, joint dislocations and bone fractures.

When the maximum load lifted is multiplied by the weekly frequency of such exertions, musculoskeletal incidents other than back episodes increased in both their frequency and severity (Fig. 13). This result is probably due to a combination of load-frequency indicating 1. greater exposure to the physical stresses which could accelerate "wear and tear" in connective tissues; 2. more potential for muscle fatigue; and 3. greater probability of uncoordinated muscle action during a lift. The fact that the low-back pain episodes did not show a similar result could indicate that people with weaker backs do not expose themselves to jobs requiring high frequency, heavy load lifting. Only people with strong, healthy backs might choose to perform such acts, and they might not be as likely to overstress the back. The evidence which follows tends to support the concept.

PERSONAL RISK OF LOW BACK INJURY

A major need in occupational medicine is to detect those asymptomatic people who are at high risk of a future low back problem when given a job requiring manual materials handling. A second need is to develop the techniques necessary to accurately diagnose the organic cause of low back pain. The latter topic is beyond the scope of this paper, although there are excellent discussions and analyses of the low back problem by Armstrong, Spangfort and others (11,13,28,30,33).

Given that a person is asymptomatic and applying for a job requiring manual materials handling, what indicates that he or she may be susceptible to a low back problem (34)? This probably is one of the most frequent questions asked of the industrial physician today. Unfortunately, the answer is not precise.

Low Back X-Rays--

Perhaps the greatest hope for detecting the high-risk individual has been the use of pre-employment lumbar x-rays. In general, this was based on the assumption that the force-bearing capacity of the spinal column when placed in many different configurations on the job is highly dependent on the radiologic characteristics

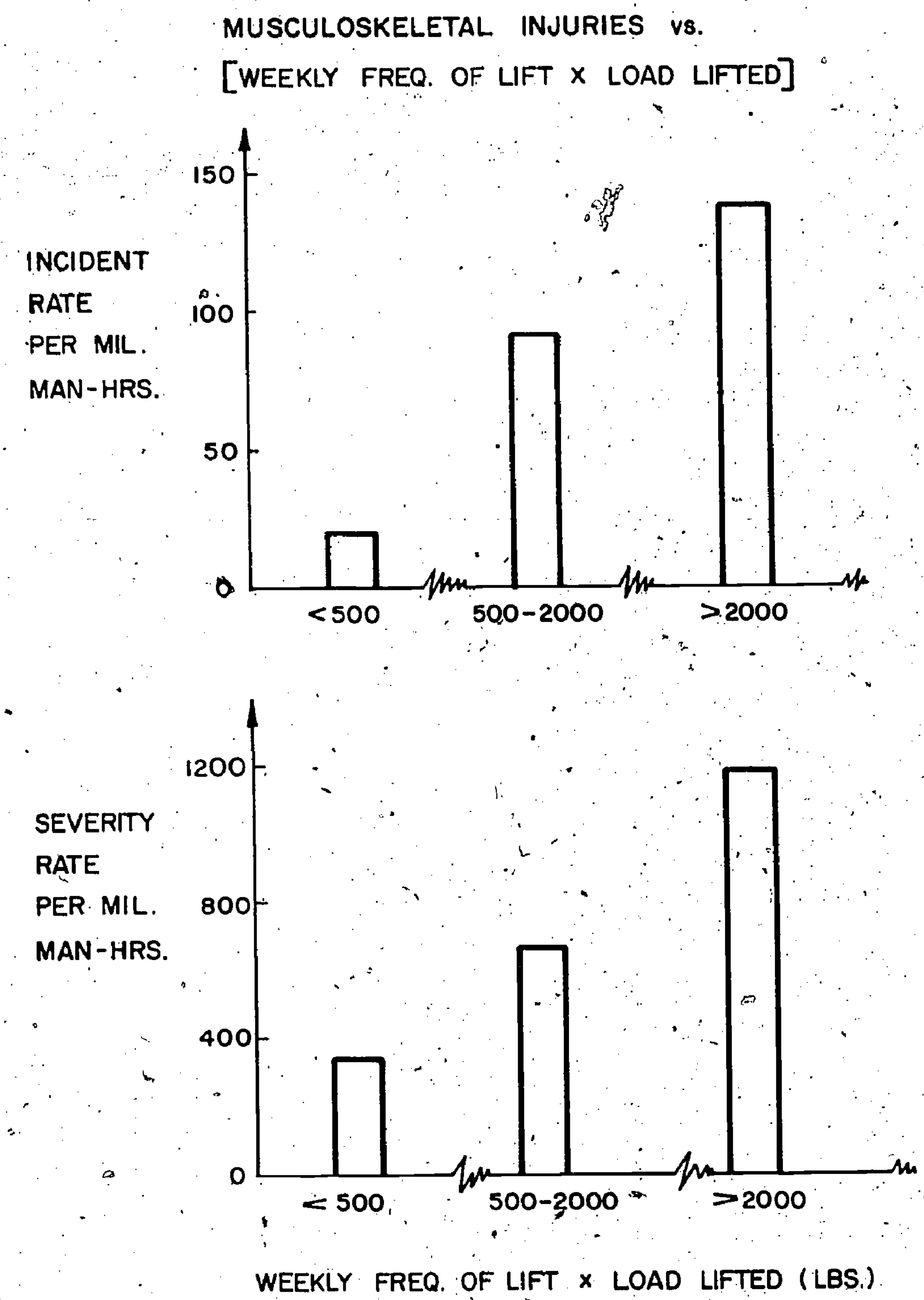


Fig. 13. Incident and severity rates of musculoskeletal injuries (other than backs) for various weekly maximum load lifting requirements on jobs. (in lbs. per week)

of the spinal column segments, as assessed by detailed evaluations of the erect, relaxed column. Many clinicians have extolled the effectiveness of such procedures in reducing the frequency and severity of low back cases in industry, particularly during the 50's and early 60's (35, 36).

Unfortunately, epidemiologic studies by various experts (13,30, 37,38) have not verified the validity of x-rays for employment screening and placement purposes when used as the sole criterion for employability. The major problem appears to arise from the fact that radiologic examinations often are part of a total "back program" for materials handling jobs. Hence, incidence statistics disclose an improvement in the number and severity of cases after the initiation of such programs, but this could be due simply to a more rigorous screening process in general.

Use of such programs often discourages people who have had back problems from applying for jobs known to have a risk of future injury (39). This does not mean that radiologic evaluations are necessary for employment examinations. In fact, with the current aim of limiting exposure to x-rays, it would appear a radiologic evaluation should be requested only if the person's low back history or medical examination raises the possibility of a skeletal defect which would limit the spinal stress-bearing capability.

To sum up, the clinical evidence supporting the use of positive radiographic findings for employment screening is weak. It is, therefore, necessary to ensure that when a specific positive radiologic finding is used to limit a person's employment opportunities, a good biomechanical basis is documented to relate the skeletal defect to the expected stresses if the person performed the job. In my opinion, in only the grossest of skeletal anomalies does such a biomechanical substantiation presently exist, because the mechanical characteristics of the involved tissues have not yet been documented sufficiently.

Low Back Medical Histories--
The alternative to x-ray-based screening appears to rest on acquiring a better history of low back health and a better functional evaluation of the person's low back. Rowe (25) has suggested that

the single most important fact when considering a person for employment on jobs requiring manual materials handling is a good medical history with concentration on low back dysfunctions. This suggestion certainly would follow from the data disclosing the recurrent nature of the episodes (13).

Support for the importance of a good low back medical history was also acquired from the study by Chaffin and Park (31) cited earlier. In this longitudinal investigation, those people who had a low-back pain incident during the 1-year study period had 3 times the number of prior incidents than those who did not suffer an incident during the study period. As Rowe (30) states, however, a person could easily distort his own medical history, intentionally or unintentionally, to acquire a job.

Lordosimetry--
Are there better ways to assess the functional capabilities of the low back? One potential method being developed by Tichauer (9) is called lordosimetry. This method relies on a device that monitors the relative locations of the spine while a person holds a load for varying periods of time. According to the initial laboratory studies, people having weak or abnormal backs disclose a specific change in the spinal column geometry when placed under load. Whether this technique has application for predicting a person's susceptibility to future low back problems remains to be proved, but it certainly demands future attention.

Height and Weight--
Often a question is raised regarding a person's height or weight as a risk factor in predicting susceptibility to low-back pain. Three separate epidemiologically oriented studies (13, 30, 31) have not supported the notion that fat or thin or tall or short people are at higher risk of a low-back problem. From the biomechanical standpoint, arguments can easily be made to support different hypotheses in this regard. For instance, an extremely tall person has longer load moment arms, thus incurring more torque at various joints when lifting or carrying an object. In contrast, however, the tall person's longer "links" enable him not to have to assume "stretching" postures to reach remote objects, thereby causing less low back stress than would be incurred by a short person

performing the same task. At the same time, if a workbench is low, the tall person necessarily will have to lean forward more than the short person, thus inducing low back static stresses of a higher magnitude than would be incurred by the shorter person (40).

In short, the selection of people for materials handling jobs based on their heights or weights is not well justified according to evidence from incidence rates. There is, however, the ever-present need to consider a person's anthropometry in relation to the physical characteristics of the prospective workplace. This concern goes beyond height and weight. All jobs that do not allow for a large range of anthropometric variation in the population, as stated in such reference books as that by Damon et al. (41) should be identified, and the specific limitations should be stated in the job descriptions. The medical department then should be prepared to select the appropriate people. Obviously, continued efforts should be made by job redesign to eliminate the anthropometric restrictions.

Strength Testing--
Some industrial physicians have adopted informal methods of strength testing to assess what a person can handle safely. One test is to ask the person to lift a tote box filled with lead shot of a quantity that produces a weight similar to the maximal lift on the job. If the person appears to be capable of lifting the load easily, he or she obtains the job. Several limitations of this particular procedure are worth noting, however: it still relies on a subjective estimate of how well the person handled the load, and the judgment may be difficult to defend. Also, such a test has the inherent danger of subjecting a person to a potentially high impulse stress they cannot readily sense and control, due to the dynamics of the tote-box lifting act.

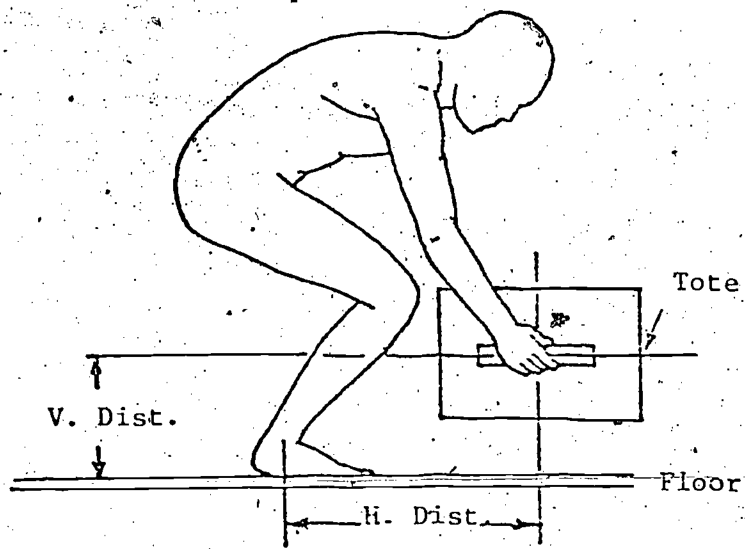
In a slightly different procedure, Rowe (30) reported persons who could perform at least one sit-up were less susceptible to low-back pain than those who could not. Specifically, he disclosed that of those people who lost time from low back disability, half could not perform a sit-up, but of a matched asymptomatic group, only 12% were that weak.

Poulsen and Jorgensen based on laboratory studies (42) suggested that torso isometric strength tests be used to predict a person's ability to perform manual materials handling jobs. It is this concept Professor Herrin and I have pursued in recent studies, (32,43) the results of which are presented here.

The first study involved the participation of more than 400 people, who were employed in jobs requiring various degrees of lifting strength. To determine this, the jobs were evaluated to determine their LSR, as explained earlier. The positions of the lifted loads which generated the highest LSR were noted. The people on these jobs then were required to perform five separate 4-second isometric lifting tests with their hands placed as indicated by the highest LSR job elements (Fig. 14). The specific testing procedure followed the guidelines of an ad hoc committee on strength testing (34).

A standardized hand position test also was performed, with the hands 50 cm away from the ankle of the leading foot and 50 cm above the floor. The results are presented in Figure 15. The women demonstrated a mean strength of about 58% of the men's. Because of the skewed nature of the distributions, the modal value of 12 kp for the females is 66% of the men's 18 kp modal value. These numbers are in general agreement with Troup and Chapman (24), who reported a women's mean of 64% of the men's mean. Their study, like many others, was performed with young, physically active subjects.

The absolute strengths demonstrated by the subjects of this study are lower than would be expected based on the earlier Danish and English studies (24,44). This may be explained by a combination of factors. First, the test procedure did not use emotional appeals often associated with past strength-testing procedures. Second, the strengths were averages of a sustained 4-second exertion, as opposed to "explosive" efforts often recorded. Third, the subjects in this study were of widely varying ages while younger groups have been studied more frequently in the past. Finally, the hand positions simulated the lifting of a large object and, as such, necessarily decreased the person's force capability, as discussed earlier.



Position of Maximum Lifting Strength Required on Job

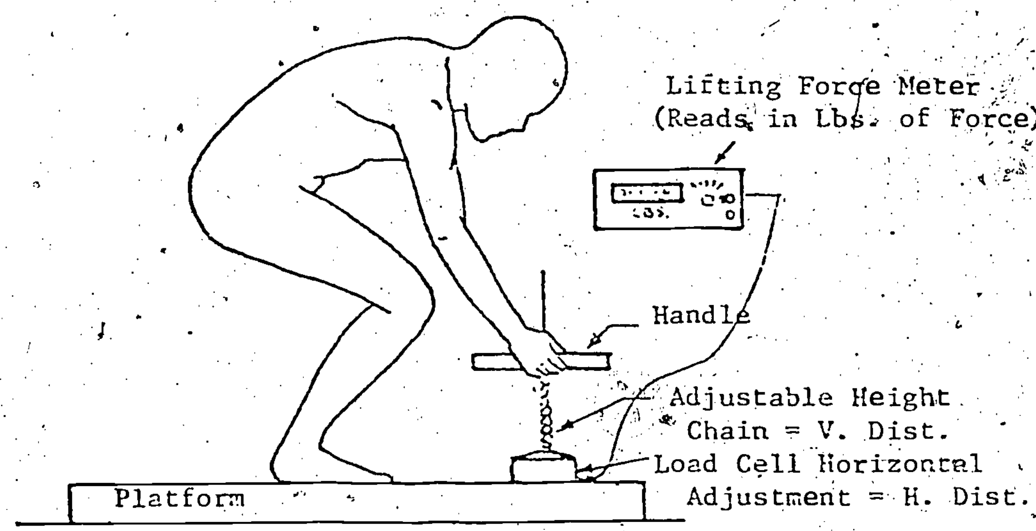


Figure 14: Comparison of job conditions and job position strength test setup

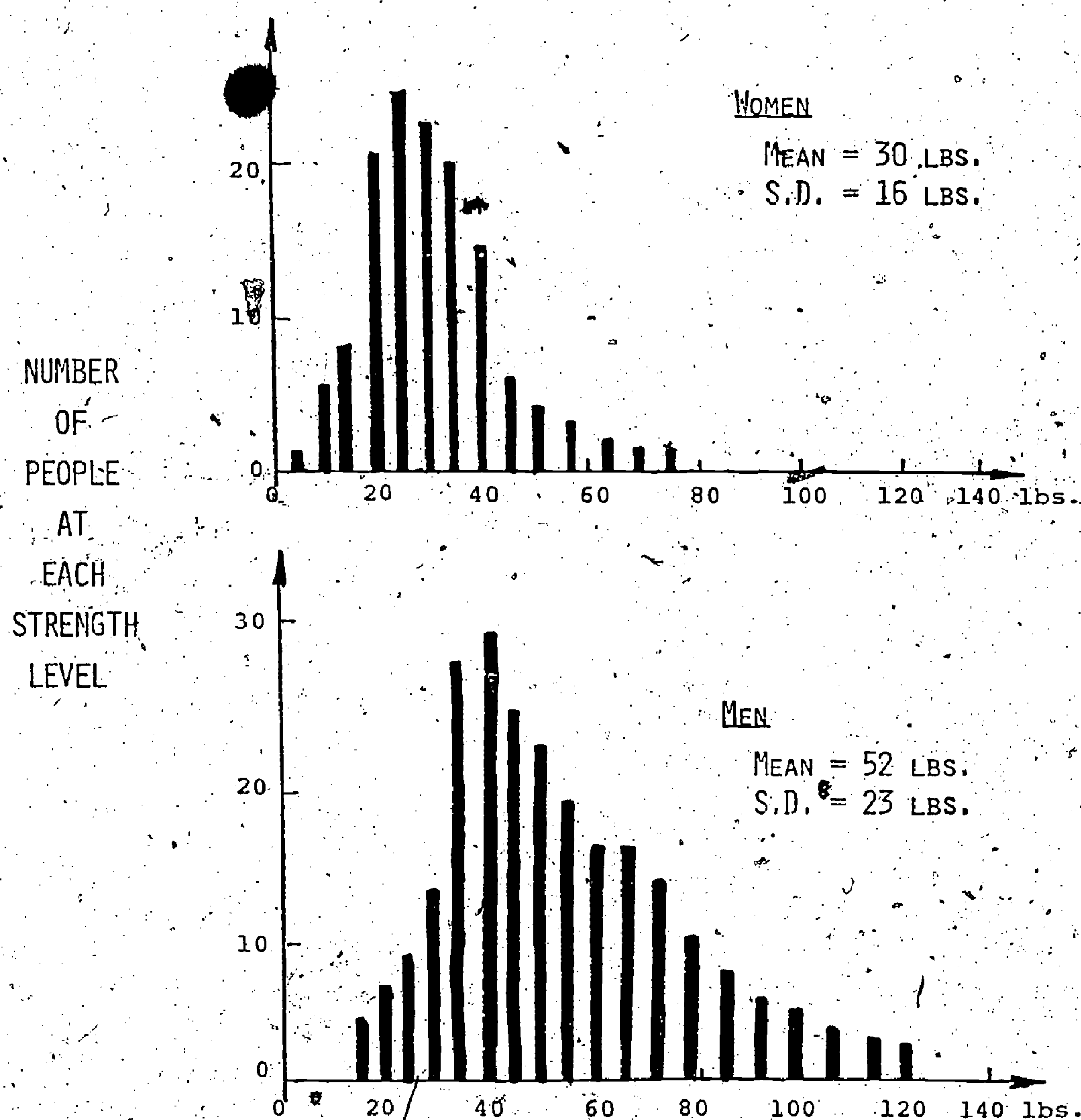


Figure 15. Lifting strengths demonstrated by employees in standard position strength testing

The male mean lifting strength values in this recent survey agree with those of Snook and Irvine (45), who tested a smaller group of workers. It is worth noting, however, that the variations in this larger sample study are at least double those reported in the Snook and Irvine study, which has been adopted as the current AIHA Guide to Manual Lifting.

It should also be mentioned that the earlier Snook and Irvine work assumed that the American female worker had a mean strength of 70% of her male counterpart. However, a more recent study (47) indicated that, depending on past physical activities, women's strength may average as low as 43% that of the strength of the male. It is reasonable to expect that if a group of women were tested who were applying for, or had held, jobs in an industry that had much work requiring considerable physical effort, their mean strength values probably would be closer to that generally reported for men (i.e., 70%).

One could characterize this as "natural" selection of people who accept certain types of work. On the other hand, if an industry is selecting women from existing jobs which require little physical effort, their resulting strength values undoubtedly will be lower. This was the situation in the data reported in Figure 15. The plants involved were classified as "light" industry, even though the people tested were performing various degrees of manual materials handling. The fact that the plants had a large number of jobs involving little physical effort, mostly held by women, tended to form a population with proportionally less strength for the women than reported in other studies. In other words, what a person has done and is willing to do physically on a job is an important factor in predicting that person's strength capabilities in future jobs.

Of all the factors affecting strength, certainly sex is one of the most important. This prompted Brown (17) to comment: "It is generally agreed that in over-all terms a woman has about 60% of the muscle capacity of a man of similar physical build. Consequently, separate standards for men and women are required."

The fact that there is so much variability in strength among both sexes certainly indicates the need for some type of testing and placement policy, which has been advocated by various leaders in the field (46). The development and evaluation of such a policy was recommended at a meeting of experts discussing the causes and prevention of low-back pain (12), and the following describes my own attempts to do this.

In the first study, a total of 25 low-back pain episodes occurred during 17,430 man-weeks of exposure to lifting jobs. These created an incidence rate (on one job) as high as 16 cases per 1,000 man-weeks. To determine whether the incidence rates for the various jobs were related to the strengths of the people on the jobs, a ratio of weight lifted on the job to the average strengths according to Job Position Strength Test of workers on that job was formed. This ratio, which will be referred to as the <u>Job Strength Ratio</u>, can be thought of as representing the strength "loading" of the employees by their jobs. If everyone were placed on a job based on their strength, this ratio would be uniform across all jobs.

Since the company involved in the study was not following any such formal procedures, a great deal of variation existed in various jobs and plants. In general, jobs with low strength requirements (LSR smaller than 0.5) were populated by people who demonstrated many times the strengths necessary to complete the job. Some of the jobs having moderate to high strength requirements were populated by workers with slightly higher strengths than required on the jobs.

Unfortunately, however, some of the high-strength-requiring jobs employed people who did not demonstrate isometric strengths equal to or greater than the weights being lifted on the job. These workers during on-job lifting were being subjected to physical stresses they demonstrated were unacceptable to them in the Medical Strength Tests. The question then becomes, "Do these overstressed people have a higher incidence rate of low-back pain than those not so highly stressed relative to their capacities?"

By dividing the job strength ratios into three groups, i.e., under-stressed, reasonably stressed, and over-stressed, and comparing the incidence rates of low-back pain episodes for each, an indication of the importance of muscle strength as a protective factor is determined. Figure 16 presents such a comparison for the first study. What is indicated clearly is a sharp increase in the mean low-back pain incidence rates for those jobs populated by persons who did not demonstrate sufficient strength to equal or exceed that required to lift the weight that generates the highest predicted stress on the job, i.e., the weight that defines the job's LSR rating.

Because of the importance of this result, a second longitudinal study was undertaken to determine if strength testing was desirable to protect people being placed on manual materials handling jobs. The study included 550 workers in both light and heavy industries. All persons were strength tested as described earlier before being placed on their jobs. Only workers going on jobs having an LSR of 0.2 (about a 35-pound lift) or greater were included. Medical follow-up on all people continued for 18 months.

Once again the data were stratified using the Job Strength Rating technique to provide three groups. This time both incidence rates and severity rates were calculated. The results are depicted in Figure 17.

As before, the incidence rate of back episodes were found ~~to be~~ almost three times higher in the over-stressed group than in the under-stressed. The people who were found to be working reasonably close to their maximum strengths, however, demonstrated a higher, though not statistically significant, rise in the mean incidence rates compared to the under-stressed group. The severity rates rose only in the over-stressed group.

When other types of musculoskeletal problems were evaluated, the Job Strength Rating did not correlate well. However, when the rating was multiplied by the frequency of weekly exertions, an increased incidence and severity rate resulted. The conclusion is that overstressing persons beyond their demonstrated strengths cannot be tolerated by the musculoskeletal system, especially when such exertions are performed more often than about 100 times each week.

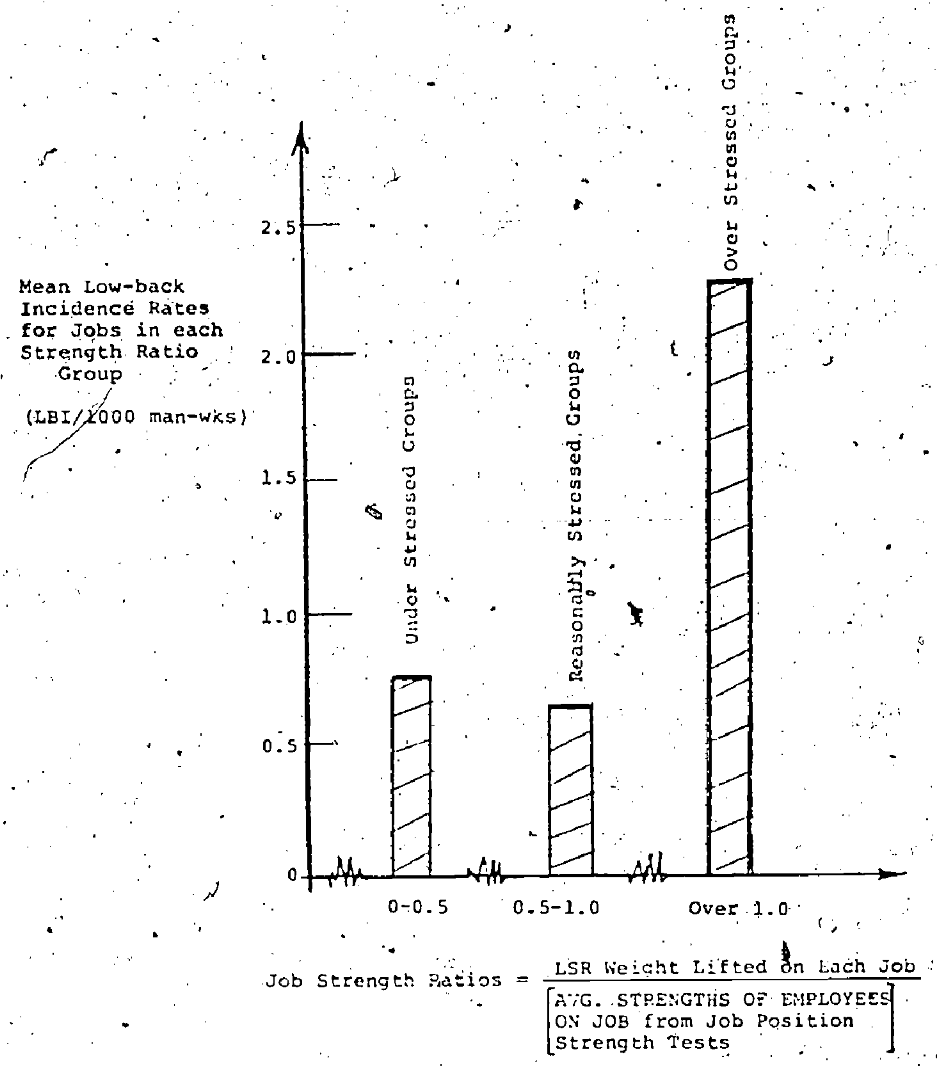


Figure 16: Job-related low-back incidence rates for jobs requiring various proportions of the documented lifting strengths of employees on the jobs.

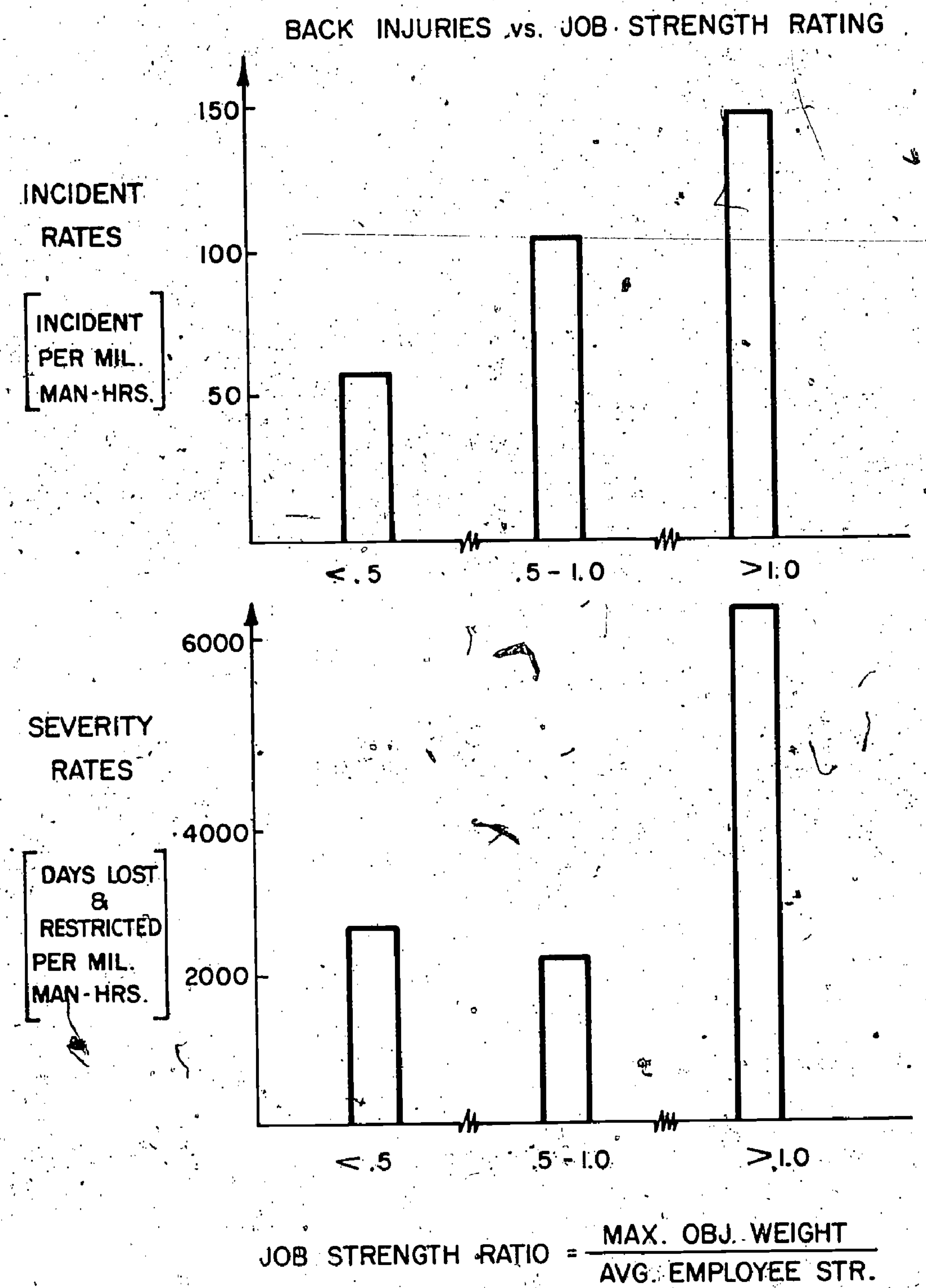


Fig 17. Incident and severity rates of back injuries for jobs having various job strength ratios

SUMMARY

Manual materials handling activities are associated with the largest number and most severe types of job-disabling injuries in industries throughout the world. One of the major medical concerns is to reduce the frequency and severity of low back cases associated with manual materials handling. This paper presented some of the biomechanical and epidemiologic factors associated with low-back pain. Since perhaps 70-80% of the world's population suffers from at least one disabling low back episode, especially involving younger workers who can be affected most of their working lives, employers should be continually concerned. The evidence indicating an increasing incidence rate also raises questions regarding the effectiveness of past preventive measures. Most of the causes of low back symptoms have not been defined, and a great deal of research still is needed about this major health problem.

From the biomechanical standpoint, evidence shows injurious levels of mechanical stress can be incurred within the low back of a person when handling even a moderate load. Also, "safe" lifting postures are not easily defined. Recommendations of such should reflect concern for the person's muscular capabilty and joint mobility, as well as for the size of the object and its positioning relative to the body.

Biomechanical considerations indicate that objects should be brought in as close to the body as possible before lifting. If small, the object should be brought between the legs using a squat leg lift with the torso near vertical. If the object is too large to pass between the legs, the person should position his feet as close to the object as possible and lift with a stooped back as opposed to the squat leg lift.

When performing lifting, hyperflexion of the back should be avoided. In addition, biomechanical considerations indicate that asymmetric or lateral lifting may be more hazardous than symmetric lifting in front of the body. Also, fast jerking actions can multiply low back stresses and are more hazardous than slow, well-controlled motions.

Unfortunately, the above recommendations have not been well validated in industrial field studies, due primarily to a lack of biomechanical descriptors of the tasks being performed. Two longitudinal studies indicated that the lifting of even 16 kp (35 lbs.) close to the body doubles the incidence rate of low-back pain cases, and lifting loads over 36 kp (80 lbs.) may result in incidence rates that are 8 times that of the more sedentary worker. Severity rates also increase greatly with higher load lifting requirements.

Major medical findings indicate that where procedures exist for biomechanically rating materials handling requirements and for rigorously evaluating employees, reduced numbers and severities of low back complaints could be obtained. More specifically, the use of a good medical history and physical examination, with emphasis on evaluating those specific functional attributes related to the physical demands of the job, appears to have the highest merit. Because lifting strength capability is a major component in materials handling, the testing of this human attribute as part of the medical examination is probably indicated in preference to other functional tests.

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DEGENERATIVE DISEASE AND INJURY OF THE BACK

Epidemiology and Differential Diagnosis in Injuries and Degenerative Diseases of the Low Back

Eugene Nordby, MD

Epidemiology is defined in the dictionary as "the branch of medicine dealing with epidemic diseases." Epidemic is defined as "affecting at the same time a large number of persons in a locality, and spreading from person to person," or "a rapid spread or increase in the prevalence of something". A Greek word, epidemia, means "staying in one place, among the people." My linguistic analysis suggests another meaning of "demi" is "half" which is about the accuracy with which injuries and degenerative diseases of the low back can be defined.

Exact figures on the numbers of annual back injuries or afflictions in the U.S.A. are hard to come by, for there is no central reporting agency. The Bureau of Labor Statistics estimates that eight million persons with mechanical difficulties of the low back annually seek care. Two hundred thousand of these individuals had surgical treatment in 1974.

In 1976, records of 2,600 neurosurgeons indicated they performed 117,000 operations on the back. That would leave 83,000 procedures for about five times as many orthopedic surgeons. It has been estimated there probably were 450,000 back operations in the U.S. in 1976. Interpolation of data compiled by the National Disease and Therapeutic Index in a statistical profile of the practice characteristics of orthopedic surgeons places 28,000 patients with back complaints under treatment by orthopedists each day of the year.

It is estimated the actual medically-related expenses are $18,000 per patient, while the associated losses of interrupted income and related benefits are $22,000. Using those figures, just the base cost of the 200,000 operative procedures would be 8 billion dollars. In addition, much money is expended on nonsurgical treatment, appliances, spa memberships, medications, and so forth.

Auto crash stories usually focus on deaths, which are easy to count. But a new study by the non-profit Insurance Institute for Highway Safety explores what is, in some ways, a more horrible and costly toll: crippling spinal cord injuries. In an average year, the spinal cords of 5,300 American drivers, passengers, and pedestrians are severed, and the majority survive but without recovery of function, continuing to be paraplegic or quadriplegic. The cost to taxpayers for their medical care is almost 1 billion dollars. The Institute suggests that one way to reduce this toll is to mandate passive preventive measures in all new cars. Another is to observe the 55 mile an hour speed limit. Yet another is to refrain from driving after drinking.

Predicting those who may develop back pain in future work has been an aim of industry for some time. MacNab and LaRocca showed pre-employment x-rays are of no help in prognostication. Rowe reported 56% of workers at age 65 had received treatment for significant back trouble. No increase in pain is noted in Scheuermann's disease--juvenile epiphysisitis, or apprentice round back in England--after adolescent age is past. Lordosis beyond 70° predicates an increase and likelihood of future back pain. Leg length difference of 3-4 cm from early age will usually cause no problem--but a later discrepancy of 2 cm after a fracture in an adult will often give trouble. Scoliotics show little or no difference in development of future back pain, as compared with that in the general population.

The best single predictor of back trouble according to Wiltse, is previous trouble, or previous surgery on the low back. As Winston Churchill spoke phrases on another topic which seem to apply to back pain: "It's a riddle inside an enigma wrapped in a mystery."

In summary, the differential diagnosis of low back injuries and degenerative diseases includes mainly the separation of those with herniating nucleus pulposus from those with hypertrophic arthritic changes, acute or chronic strains or sprains, fractures, rheumatoid spondylitis, and tumors.

In a study of risk factors in the development of herniating lumbar intervertebral discs, Kelsey and Horly found that the driving of motor vehicles increases risk. People of either sex who drive cars regularly were more apt to develop an acute disc herniation than those who did not drive. Men who spent one-half or more of their time on their job driving are three times as likely to develop disc herniation as those who do not hold such jobs.

Truck drivers are particularly prone to develop disc problems unrelated to lifting. The relative risk with sitting while driving is nearly twice as high as with sitting in a chair. Driving seems to be productive of L4 level disc problems, rather than those at L5-S1. Back pain in predisposed subjects is more likely to occur in sports car type seating with the legs almost straight in front, rather than in seats designed more like a chair.

The differential diagnosis of causes of low back pain and sciatica can be viewed as a list of various possibilities. (Table 1)

Table 1. Differential diagnosis: causes of low-back pain and sciatica

- Protruded intervertebral disc
- Hypertrophic arthritis of the lumbar spine
- Rheumatoid spondylitis
- Spondylolithisis
- Spinal cord, nerve root or sciatic nerve tumor
- Intervertebral space infection
- Bone tumor
  - Osteoidosteoma
  - Eocenelphelicoma
  - Primary malignant tumor
- Metastatic malignant tumor
- Multiple myeloma
- Hypertrophic arthritis of the hip
- Paget's disease
- Neuritis, especially diabetic neuritis
- Psychoneurosis
- Malingering
- Septic arthritis of the sacroiliac joint
- Twisted ovarian cyst
- Pelvic endometriosis
- Glomus tumor
- Occlusive disease in aorta or iliac vessels
- Spinal stenosis
- Fracture of vertebral bodies or processes
- Strain or sprains
- Osteoporosis

We will limit our attention to injuries and degenerative diseases of the low back, not considering tumors, infections, metabolic disease, and pelvic disorders. Whether psychoneurosis and malingering is secondary to injury depends on the psychiatrist and attorney.

Ordinarily, it will be possible to arrive at a reasonable assessment of the cause of the trouble with a good history, physical examination, and roentgenograms of the lumbosacral spine. Refinements in the diagnosis may depend on special tests. It is fair to state that more mistakes are made from not looking than from not knowing.

It may be helpful to differentiate posterior division syndromes from anterior division nerve root syndromes in categorizing patients, while keeping in mind that psychogenic symptoms can mimic discogenic symptoms quite accurately. Etiologic factors in posterior division lesions include:

strains, such as postural or leg inequality,
sprains at ligamentous and tendonous attachments,
tension states,
and some bony injuries of vertebrae and their processes.

Radiated pain in these situations is not a true referred pain but is what Luck calls "reflex radiation," which has less sharply defined boundaries, is more variable in extent, and is less persistent.

Anterior division syndromes include the herniating nucleus pulposus as the most common course, but tumors of the spinal cord, nerve root, or peripheral nerve need to be excluded, as well as some instances of hypertrophic arthritis of the back of hip, spondylolysis, spinal stenosis, or occlusive diseases of the aorta and iliac arteries.

Of help in the differential diagnosis of back pain is the fact that radicular pain is usually linear and central pain is more of a diffuse ache with some sensory diminution. Tumor pain is often severe at night during rest, while disc pain when it occurs at night is often secondary to movement.

In attempting to differentiate degenerative arthritis pain from discogenic pain, early morning stiffness may be of help, but this is often not conclusive. Frequently, a trial of anti-inflammatory medication for 10 days and the response to it can be a deciding factor. Hypertrophic arthritis of the hip as the cause of leg pain can sometimes be determined by limitation of hip motion and pain on extremes of motion, especially of rotation, but also by the addition of Kernig's tests to straight leg raising. Increased pain with this maneuver should incriminate nerve root pressure.

Rheumatoid spondylitis can attack a seemingly healthy young or adult male complaining of back pain with or without sciatica. Often the pain will be dorsal initially, and later it may be accompanied by diminution of chest expansion. Roentgenographic evidence of sacroiliac joint destruction is helpful in differential diagnosis.

Spinal stenosis in the lower lumbar area and occlusive vascular disease may be difficult to differentiate clinically, if vascular deficit is apparent in one or both extremities. Symptoms of increasing pain and numbness of the lower extremities with decreasing amounts of activity may be present in both. While roentgenograms may be helpful in showing aortic or iliac calcification, or spinal cord narrowing, it is usually necessary to include vascular studies, electromyography, and myelography to be definitive in the diagnosis. Spinal fluid determination can, of course, be helpful in differentiating tumors and disc protrusion, since the spinal fluid protein is seldom above 60 mg or 80 mg per 100 ml in the latter.

Routine roentgenograms can be most helpful in determining congenital anomalies, pedicle defect of spondylolysis, hypertrophic changes of spondylosis, changes secondary to fracture or infection, tumor, or metabolic disorders.

Demineralization of the spine, osteoporosis, is a source of disabling pain of insidious onset, which is seen mostly in mature females and can cause back pain and/or sciatica of excruciating severity accompanied by compression fractures, rib fractures, and the like due to only normal muscle tension.

It is claimed that 25% to 50% of all back pain includes a psychological factor, either as contributing cause or as the exclusive cause of the disability. Since I am neither a psychologist nor a psychiatrist, I feel it incumbent upon me as an orthopedist to make doubly certain that I am unable to find an organic basis for complaints before I label them psychological. Knowing that both factors may be present often presents a challenge in diagnosis and treatment. We do use the Minnesota Multiphasic Personality Inventory (MMPI) as a screening device, and it is often helpful in evaluating findings to identify those patients with hysteria and hypochondriasis.

DEGENERATIVE DISEASE AND INJURY OF THE BACK

Radiologic Examination of the Lumbosacral Spine

Louis Gilula, MD

RADIOGRAPHIC ANATOMY

Before showing you entities that may be seen on a routine radiographic lumbosacral spine examination, I would like to review briefly the radiographic anatomy of the normal spine. The vertebral body is normally concave on its anterior and lateral margins, and its superior and inferior surfaces, or end plates, are flat. Two pedicles arise posteriorly from the body and connect the vertebral body to the posterior elements. The pedicle unites the body to a posterior bone mass, of which the superior and inferior extensions are the superior and inferior articular facets. The bone between the superior and inferior articular facets is the pars interarticularis, or the isthmus. Two broad bony structures extending medially from the facets to join the spinous process are the laminae, and the transverse processes extend laterally from the superior articular facets at the level of the pedicles.

The lateral borders of the spinal canal are outlined by the pedicles on the anteroposterior view. On the lateral view, the posterior aspect of the body forms the anterior margin of the spinal canal, and the anterior surface of the laminae and the base of the spinous process form the posterior aspect of the spinal canal.

As is best seen in a lateral radiograph, the intervertebral disc spaces are the same width or become progressively wider between L_1 and L_4 and should not be narrower than the disc space above. The L_5 - S_1 disc space may be narrowed up to one-half the width of the above disc space without being abnormal. Our routine lumbosacral spine views include anteroposterior, lateral, both obliques, detailed lateral of the L_5 - S_1 disc space, and an anteroposterior up-angled view to profile the L_5 - S_1 space. Optionally stress views in lateral flexion and extension, and in anteroposterior lateral bending positions, may be obtained.

CONGENITAL ABNORMALITIES

Many congenital abnormalities and normal variants affect the lumbar spine, but I shall show you only three: spina bifida occulta, hemivertebra, and unfused inferior articular facet apophysis. Spina bifida refers to a defect in the vertebral arches, through which spinal membranes with or without dura and its contents may protrude. Patients with this type of defect may have neurologic symptoms. Spina bifida occulta (SBO) has a defect in the vertebral arch, but there is little or no protrusion of spinal membranes through this defect. Occasionally, the site of this defect may be identified on the overlying skin by the presence of a dimple, or a hair. Radiographically, SBO is most common at L_5 - S_1, and less common at T_{12} - L_1 levels.

A hemivertebra is a bone comprised of part of a vertebral body and posterior elements, which may be separate or fused to an adjacent vertebra. This extra wedge of bone between two adjacent vertebra creates a scoliosis due to the additional bone on one side of the vertebral column.

ACQUIRED ABNORMALITIES

Of the numerous acquired lesions with radiographic findings, I shall present Schmorl's nodes, degenerative conditions of the spine, disc space infection, spondylolisthesis, isthmus defects ("spondylolysis"), diffuse idiopathic skeletal hyperostosis (DISH), and ankylosing spondylitis.

Schmorl's nodes are frequently seen throughout the thoracic and lumbar spine. These are defects in the cartilage end plates of vertebral bodies, through which disc material herniates. One idea about their development is that the cartilage end plates congenitally are weak in these individuals, and minor stress causes disc herniation through the weakened area, resulting in the typical radiographic appearance of a rounded defect in the end plate. The nodes may occur anywhere on the superior or inferior surfaces of the vertebral bodies. They are usually asymptomatic and without clinical significance, but some physicians feel that at the time the nodes formed, the patient had some discomfort. When vertebral end plate defects are sharp and at right angles to the disc, sickle cell anemia is a main consideration.

DEGENERATIVE SPUR FORMATION

As we walk erect, disc material normally compresses and bulges outward, and ligaments that are attached to the periphery of the vertebral bodies may be slightly elevated. Microhemorrhages may occur under these elevated ligaments, and bony spurs (spondylosis) may develop, even in the absence of a degenerative disc process. Weight bearing compression forces cause some of the fluid to be expressed from each intervertebral disc, so that daily we actually lose a small amount of height. In normal discs, the fluid is regained during sleep and rest.

Degenerative spur formation is found most commonly along concave portions of the spinal curves, as along the anterior thoracic spine seen on the lateral view of a routine chest examination, or along the concave side of a scoliotic curve. Degenerative spurs are usually not associated with clinical symptomatology, other than decreased range of motion.

DEGENERATIVE DISC DISEASE

Degenerative disc disease develops when the disc loses its structural integrity and begins to degenerate. As it degenerates, the patient may be asymptomatic; however, disc elements may herniate with or through a weakened annulus fibrosus, impinge on nerves, and produce neurologic symptoms. As the disc degenerates, it loses its cushioning effect, and the disc space may narrow with subsequent reactive changes of the opposing vertebral margins.

Reactive bone changes may be manifested as spurs larger than in an asymptomatic person, since the degenerating disc may bulge even more, elevating the adjacent ligamentous structures with more microhemorrhage and osteophyte formation. Bony sclerosis and thickening of the opposing vertebral margins may be present to a minimal or to a very extensive degree. An additional feature of degenerative disc disease is the presence of a vacuum phenomenon. With degenerated disc material there may be a potential space within fissures in the disc, which when distracted, for instance by hyperextension, fills with gas. This gas has been analyzed (1) and found to be 90%-92% nitrogen. Inert nitrogen readily goes into and out of solution at the tissue level, where it is more available than oxygen or carbon dioxide.

Reactive changes of degenerative disc disease involve both sides of a disc space. The cortical margins of the vertebral bodies are usually intact, although they can be very irregular. This can serve to differentiate degenerative disc disease from disc space infection. Disc space infection often has striking disc space narrowing, but usually there also is cortical destruction without hypertrophic spur formation.

DEGENERATIVE JOINT DISEASE (OSTEOARTHRITIS)

Degenerative joint disease is a condition where synovial joints undergo degeneration with hypertrophic bone formation and sclerosis of medullary bone. In the lumbar spine, the synovial joints are the apophyseal, or facetal joints. Occasionally, degenerative joint disease may be present without gross radiographic degenerative <u>disc</u> disease, and the opposite may also occur: degenerative disc disease may be present without gross radiographic degenerative <u>joint</u> disease. However, they generally occur together. Reactive bone formation may be very prolific, and indeed at times, hypertrophic bone formation along the apophyseal joints may simulate a fracture of the facet. With knowledge of this possibility laminograms may show that the facet in question is intact.

SPONDYLOLISTHESIS

Spondylolisthesis may develop from isthmus defects or from apophyseal degenerative joint disease in the absence of an isthmus defect. With increasing hypertrophic bone formation along the margins of the facet spaces, and with associated ligamentous laxity, the vertebral body above may move forward. An additional feature that appears to take place is alteration of the orientation of the facets. Over the years, the normal vertical orientation of the superior and inferior facets may become slightly more horizontal, helping spondylolisthesis develop. With spondylolisthesis and degenerative joint disease at the same level, degenerative disc disease is usually associated.

DIFFUSE IDIOPATHIC SKELETAL HYPEROSTOSIS (DISH)

A condition that probably is not familiar to most of you has been described recently in the radiologic literature (2,3) and in the <u>Archives of Internal Medicine</u> (4) by Doctor Resnick of the VA Hospital at San Diego. Historically, various features of this entity have been described as Forestier's disease, senile ankylosing hyperostosis, and by several other names. In this condition, the disc spaces are normal, but there is extensive hypertrophic bone formation along the margins of the vertebral bodies, especially anteriorly and anterolaterally. In the past, huge bone formation in the cervical spine was described, which occasionally could cause dysphagia. In some cases, passing an esophagoscope tore the esophagus on these large spurs. Occasionally, surgical removal of spurs has been necessary.

Doctor Resnick examined many patients with this condition, found these patients to have an ossifying diathesis, and described them as "bone formers." DISH is felt to be present when (1) at least four vertebral segments are involved with "flowing calcification and ossification along their anterolateral aspects; (2) intervening disc spaces are relatively preserved; (3) apophyseal joints are not ankylosed; and (4) sacroiliac joints are not eroded, sclerotic, or fused."

These patients may have tremendous proliferation of ossification at ligamentous insertions practically anywhere in the body, but especially around the pelvis, hips, and calcaneus. Due to the large size of spurs and ankylosis, there can be limitation of motion. Other than occasional tendonitis, minor arthralgias and heel pain, the patients have little symptomatology. Potentially, it may be of value to recognize these patients as bone formers, so that if one of them has an operation near bone, one might expect more than the usual postoperative bone formation.

ANKYLOSING SPONDYLITIS

Typical, late stage, ankylosing spondylitis also fuses vertebral bodies, but without the prolific bony bridging of DISH. Ankylosing spondylitis may also fuse posterior elements and sacroiliac joints. Earlier stages of ankylosing spondylitis may present only with squaring of vertebral body corners, and may or may not have inflammatory changes of the sacroiliac joints.

MISCELLANEOUS

Old fractures may be recognized by vertebral deformities and and by smooth bony bridging of cortical fractures.

Neoplasms may be primary in the vertebral column. Osteoblastoma and osteoid osteoma are primary lesions common to the posterior elements, especially in younger people. Osteosarcoma, the most common primary bone malignancy in young people, may also involve the spine. In persons over 40 years of age, metastases and myeloma are the most common malignant bone lesions, and they also affect the spine.

These are some of the common and uncommon lesions that may be seen upon roentgenographic examination of the lumbar spine.

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DEGENERATIVE DISEASE AND INJURY OF THE BACK

Chemonucleolysis in the Treatment of Lumbar Disc Disease

Henry W. Apfelbach, MD

Chemonucleolysis is the injection of an enzyme, chymopapain, into the intervertebral disc space. Lyman Smith working with Ivan Stern and Robert Gesler started an investigative program in 1963 to determine the efficacy of this procedure. Smith and Brown enlarged upon the original technique of Lindblom in diagnostic disc puncture, with injection of radiopaque medium to demonstrate various pathologic states of the intervertebral disc. Thus far, chemonucleolysis has been done in over 15,000 patients in the treatment of discogenic pain.

ANATOMY AND PHYSIOLOGY OF THE INTERVERTEBRAL DISC

The intervertebral disc is composed of three parts: the cartilaginous (hyaline) endplate of the vertebral body; the annulus fibrosus, a meshwork of very dense collagenous fibers which surrounds and encloses the disc material and is attached to the adjacent vertebral bodies. A less dense meshwork extends into the central regions of the disc material; and the nucleus pulposus, which occupies the center of the disc space and is composed of a thin meshwork of collagenous fibers with mucoprotein gell (with bound water) in the interstices.

With aging, there is depolymerization of mucoproteins and decrease in water content in the disc. This change is commonly termed "degenerative disc disease."

CHYMOPAPAIN

Chymopapain is an enzyme isolated from the latex of the papaya. This enzyme in contact with the disc causes depolymerization of mucoprotein but has no effect on collagenous structures such as the annulus fibrosus, the ligamentous structures about the vertebral column, or the sheaths of nerve roots. Studies by Gesler on animals with usual therapeutic doses of the enzyme have shown a several hundredfold margin of safety of chymopapain when properly injected in the disc space.

INDICATIONS FOR CHEMONUCLEOLYSIS

The indications for chemonucleolysis are the same as those for laminectomy: failure of response to conservative treatment (absolute bed rest for 10 to 14 days); frequent recurrent episodes of sciatica; and inability to pursue gainful employment. It is my opinion that chemonucleolysis will eventually find its place between conservative treatment and open surgery, the latter to be done when chymopapain injection fails to relieve symptoms. With chemonucleolysis, instability caused by the surgical approach to the disc is avoided. Further, the patient does not have evidence of an open surgical operation on his back, which frequently prevents his being hired.

Chemonucleolysis should be considered if laminectomy has failed, especially in that group of patients who achieved a satisfactory clinical result which lasted for one year or more following their laminectomy. A second laminectomy frequently fails because of inability of the surgeon to penetrate scar and reach the area of pathology. In many of these patients, repeat laminectomy also creates additional scarring and further increases instability of the low back.

CONTRAINDICATIONS

Contraindications to chemonucleolysis are as follows:

1. Rapidly developing neurologic deficit in which paraplegia is feared. In this instance, immediate laminectomy is indicated.
2. Severe neurologic deficit, e.g., foot drop, or evidence of cord bladder, in which the probability of completely extruded fragment of nucleus pulposus is high.
3. Spinal stenosis: the incidence of spinal stenosis, or narrowing of the spinal canal, is greater with increasing age. The syndrome of spinal claudication in the absence of a Leriche syndrome should suggest spinal stenosis. The patient's sciatica occurs chiefly on walking. Spinal stenosis can be adequately diagnosed only with myelography.
4. Patients who have been diagnosed as having arachnoiditis; this group of patients almost invariably has had at least one myelogram and one laminectomy.
5. Pregnancy.

6. Previous chemonucleolysis. Risk in this group of patients is purely theoretical (increased chance of anaphylaxis).

PREOPERATIVE EVALUATION

In addition to routine admission history, physical examination and routine laboratory studies including electrocardiography, the following should be considered:

1. Electromyography, performed by a proficient electromyographer, is of value if fibrillation potentials can be shown. A negative electromyogram, however, does not rule out the presence of a herniated disc.
2. Myelography, if chemonucleolysis is anticipated. This procedure's main value is that of ruling out spinal stenosis and spinal cord tumor.
3. Epidural venography.
4. Psychometric testing (Minnesota Multiphasic Personality Inventory) is, in general, regarded to be the most reliable test in prognosticating the effectiveness of chemonucleolysis or laminectomy.

TECHNIQUE OF CHEMONUCLEOLYSIS

Chemonucleolysis may be done either in the special procedures room of an x-ray department or in the operating room. Many surgeons prefer general anesthesia because the patient is intubated and can be maintained with an open airway in the event of anaphylactic reaction to the enzyme. Others prefer local anesthesia.

After being anesthetized, the patient is placed on his left side with elevation of his left flank so that the pelvis "falls away" and tilts to the right. Each surgeon has a somewhat different technique for achieving this position, and special radiolucent operating tables are often used.

Following surgical preparation of the patient, discography is done under fluoroscopic control through the lateral approach. With this approach, it is unnecessary to penetrate the dura. The needles are placed "bull's eye" in the center of at least the lowest two disc spaces, and very frequently the lowest three disc spaces. One to five cm of a water-soluble dye (Conray 60) is injected into each disc space. Roentgenograms are taken in both the anteroposterior and lateral projections and usually reveal one of the following: (1) a normal disc, (2) a degenerated disc, (3) a protruded disc, or (4) an extruded disc, which is suggested by an epidural leak of the dye up and down the spinal canal.

In general, abnormal discs, including those which are "degenerated," are subjected to chymopapain injection. The ideal dose appears to be 3,000 units. Most investigators have felt that the degenerated intervertebral disc should be subjected to chymopapain injection because the degenerated disc of today may become the herniated disc of tomorrow. Following injection of chymopapain, the patient is monitored for anaphylaxis.

POSTOPERATIVE TREATMENT

The only thing predictable about chemonucleolysis in the immediate postoperative period is its unpredictability. Many patients awaken completely relieved of back pain and sciatica. More important, however, in predicting the effectiveness of a chymopapain injection, is the relief of sciatica, or at least a change in the character of the patient's sciatica, during the next few days.

Virtually all patients are able to get up to go to the bathroom on the evening of surgery. The level of activity is regulated on an individual basis. Patients are told to avoid sitting as much as possible. They remain recumbent but may take frequent short walks. Patients with severe low back pain should be treated with hydrotherapy. Muscle relaxants and William's exercise appear to be of no value. Average hospitalization is four days.

In general, the patient should remain out of work a minimum of three weeks from a sedentary occupation and six weeks from light labor. The results of chemonucleolysis are covered in the paper by Dr. Eugene Nordby.

COMPLICATIONS

1. Anaphylaxis: the incidence of anaphylaxis is slightly less than 1%.

2. Traumatic neuritis: with improper technique the spinal nerve can be traumatized at its point of exit from the intervertebral foramen.
3. Post injection backache: this may be prolonged. It is our opinion that its incidence is significantly reduced by a program of steroid therapy for the first four days following injection.
4. Disc space infection: we have not encountered this rare complication.

JOB STRESS AND WORK PERFORMANCE

Introduction

Herbert C. Modlin, MD

The phrase, "job stress," merits a few moments' scrutiny. Is it shorthand for "the stress of the job"? If so, does that imply that his job may be a stress which impinges on the worker? We can interpret "job stress" to mean that some jobs produce in workers a state of stress which then impairs their task performance. Where does stress properly lie: is it external stress which upsets the worker, or should his internal upset be labeled stress? Is stress then a subjective feeling or are there objective evidences of its presence or absence? And, is stress essentially distressful; or should it be considered normal, even desirable? As a matter of fact, "stress" has been used in the literature in all the senses I have indicated.

For us in medicine, a useful and congenial frame of reference lies in the interlocking work of Claude Bernard, Walter Cannon and Hans Selye. From this physiological perspective, stress is not something imposed on the organism; it is a response state induced by a stimulus, a stressor. Stress as a life experience is as inevitable as pain or anxiety and as useful; complete freedom from stress is death (1). Only excessive stress which unbalances homeostasis is experienced as stressful.

Students of psychological stress have not been so precise or so limited as Selye. Most researchers agree on the definition that considers stress a response phenomenon, not something external to the personality (2). The response may be in certain types of overt behavior, autonomic nervous system reactions, purely subjective feelings such as anxiety, fear or anger, or in adaptations sufficiently deviant from a norm to be labeled illness. In the psychological, psychosomatic, and psychiatric literature, stress is commonly thought to be distressful and undesirable. The stressor event produces an organismic process which strains the adaptive capacity and threatens disruption of physiological and psychological integrity.

Peculiar to discussions of psychological stress is the individualistic, idiosyncratic interpretation of life events as stressors: "One man's meat is another man's poison." As conceptualized by Hinkle, for the human organism to experience stress (an undesirable state) three conditions are necessary: a basic susceptibility to stressors in general; exposure to a significant change in environment or interpersonal relations; and interpretation of that change as a stressor, i.e., as dangerous and threatening (3).

In the past 10 years, several groups of investigators have attempted to refine and measure the relationship between stressors in the environment and states of psychological stress in the individual. Most of their reports have been published in psychiatric journals. Holmes and Rahe developed a 42-item Schedule of Recent Experiences, and in a series of articles have related the quality and quantity of life changes to the onset of illness (4). Holmes and colleagues developed a social consensus scale by asking research subjects to rate the original 42 life experiences in terms of importance and severity. From that rating a crude quantitative estimate of the stress-producing potential of life changes is possible. "The greater the magnitude of life change (or life crisis), the greater the probability that the life change would be associated with disease onset..." The seriousness of the disease and the magnitude of the change were also positively correlated (5).

To the question "What are the characteristics of a life event that make it a stressor?", most answers emphasize the degree of change the event causes in the individual's usual activities. Forced change demanding deviation from established coping patterns is most apt to result in second level, second rate coping (symptoms). The accompanying anxiety is very probably the key element being measured in the various life change scales.

Paykel and associates refined the Holmes-Rahe schedule into an enlarged list of 61 items covering more facets of life experience, and asked their subjects to rate them on a scale of 0 (least upsetting) to 20 (most upsetting) (6). By appropriate statistical treatment, each item emerged with a mean number. The 61 items were then placed in rank order. The highest rating by consensus (19.33 out of a possible 20) was "death of a child." Death of a spouse (18.76) ranked second, jail sentence (17.60), third; then followed unfaithful spouse, major financial difficulty and business failure.

The least stressful of life change events was marriage of a child with respondents' approval (2.94). Next above this event were such items as a wanted pregnancy, becoming engaged, beginning one's education and moving to another home within the same city. Of items referring to work, the absence of work was rated most distressful; being fired was number 8 on the list (16.45); being unemployed for at least one month came in fifteenth.

Concerning factors related to actually holding a job, demotion ranked seventeenth; but the next item, arguments with boss or co-worker, was well down the list -- number 30. Below that were change of work hours, change in career, change of work conditions, a move to another city; all were considered less stressful than onset of menopause, taking an important examination, or separation from a close friend. An overall impression is that in the conscious thinking of the research subjects, work is not a prominent source of stress.

Additionally relevant to this discussion are data from Ilfeld's work (7). He and colleagues found, in a random sample of Chicago residents, a quantitative relationship between stressors and clinical depression. Of his respondents having no social stressors in their current life situation, two percent were depressed. Of those clearly having one stressor, the incidence of depression was seven per cent; with two stressors, fourteen percent were depressed. With three or more concurrent stressors, the incidence of clinical depression rose to thirty-four percent.

There appears to be a cumulative quantitative effect more or less independent of the specific nature of each stressor. It seems to matter little whether the burden is an alcoholic husband, death of a parent, unemployment, a sick child, an extramarital affair, or inadequate housing. Anyone living with three such stressors is in a high risk group for depression. At the same time, the Ilfeld data show that sixty-four percent of those so afflicted did not develop depression, suggesting that individual strengths and susceptibilities and social support systems also influence coping capacity.

Using different test populations and different research techniques, several groups of investigators similarly conclude that the number, severity, frequency, and duration of stressful life events correlate with untoward reactions or illness. A possible, though tentative, conclusion is that an employee who appears substantially stressed by aspects of his work should be interviewed concerning other possible adverse events in his present life or recent past. If further studies replicate Paykel's findings, we shall need to evaluate the general conclusion that job-related stressors do not alone ordinarily effect significant incapacity.

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WORK STRESS AND JOB PERFORMANCE

Variables in Occupational Stress

Tobias Brocher, MD

Hans Selye devoted his last edition of "Stress in Health and Disease"

> "To those who are under the exhausting nervous strain of pursuing their ideal--whatever it may be. To the martyrs who sacrifice themselves for others, as well as to those hounded by selfish ambition, fear, jealousy--and worst of all by hate. For my stress stems from the urge to help and not to judge."

This authoritative scientific volume, based on research beginning during the thirties and earlier, reflects a basic dilemma: Everything is possible under stress--physiological reactions with secondary psychological consequences; as well as psychological, psychosocial, and sociocultural stressors which can cause psychosomatic and physiological changes and stress adaptation syndromes.

Since newspapers, magazines and other media teach us daily about stress and its consequences, the public seems to have become more expert than the physician. In some professions it seems to be the confirmation of aggressive, successful ambitiousness when an executive can diagnose himself as a "Type A personality." The ambivalence between pride and repressed fear of potential health hazards from this modern self-diagnosis reveals more clearly a certain oversimplification of any typology. The latter fits our need for stereotypes, but it distorts the complexity of the multifactorial sources for stress.

The information to be presented here is based on more than 20 years of experience with workers who attended the former Menninger Seminars for Industrial Mental Health, founded by Dr. William Menninger in 1956. During this time, more than 20,000 workers from all walks of life participated in intense five-day seminars, three-day workshops and individual and organizational consultations. The average U.S. worker in 1977 is different from the average executive in 1956 because the work environment, value system, and life conditions have radically changed.

From our regular seminars for occupational physicians (since about 1957), we have recognized two factors that are related to specific stress within this profession:

1. the relatively short training in modern psychiatry and the difficulty in coping with psychological elements,
2. the lack of time, which would ease the decision that management wants to convey to a given individual under medical scrutiny.

Whatever happens, the accountability rests with the physician. One of the best examples for such a double-bind situation is the responsibility of the flight surgeon to diagnose the amount of stress which a 32-year-old air traffic controller claims as the reason for early retirement or vocational change after 5 years of service.

If we expect to obtain reliable data from an investigation of stress conditions, the study must be based on:

1. a general health survey,
2. a personal history survey, including early childhood and psychosocial development data, and
3. an organizational survey (i.e., methods of performance evaluation, patterns of supervision, degree of job satisfaction, perception of work conditions, potential for career development) (1).

Within this framework will be numerous variables related to specific health factors, elements of personal history, or organizational conditions that can lead to various stress syndromes. Although general folklore alleges that the pressures of decision-making in management positions inevitably cause stress which then leads to cardiovascular syndromes, we have sufficient evidence that this general assumption cannot be validated. Depending on various factors, stress syndromes usually are seen to be related to:

1. The particular position within an organization (i.e., operations, staff, or management) and the specific functions within substructures of the position (e.g., the linkage between different groups, sub-leadership functions, and/or degree of accountability). For example: Job

satisfaction and job performance are interrelated only for workers in nonstimulating jobs, while there is higher satisfaction but lower performance level in stimulating positions (1).

2. Qualitative differences in stress tolerance based on the individual sociocultural background, which also includes differences of age, sex, and education as well as the individual personality history (i.e., traumatic factors in various life events, sequence of life change units (2), prevalent mood, and defense patterns).

Recent research has confirmed five main hypothetical types of stress symptoms related to specific organizational work tasks and/or positions:

1. varying degrees of emotional distress without physical symptoms,
2. cardiovascular conditions in different progressive stages,
3. gastrointestinal disorders of varying degrees,
4. respiratory allergy, and
5. medication use or abuse (3).

Our primary task is to identify which stress factors are directly work-related, which are the result of organizational pressures and/or specific subgroup dynamics, and which are carried over from personal conflict situations in the family or during crucial development periods of the life cycle. Throughout the years we have found certain typical constellations in various age groups. As a principle, we have observed periods of higher stress symptoms in younger, ambitious workers who are striving for achievement and recognition. Reaching the expected goal is usually followed by a higher intensity of stress symptoms, especially in case of promotions and/or new task assignments. Although the subjective perception of job satisfaction increases, the uncertainty of the new work situation prevails until sufficient adaptation has been reached. Missing the expected goal leads to increasing stress symptoms through frustrated aspirations. A vicious circle develops when the reality perception is distorted and the efforts to accomplish the envisioned goal neglect given limitations. The self-inflicted stress can lead to unconscious self-destructive attitudes.

We have previously assumed that the place of work is causally related to stress. This may be true for certain work conditions such as excessive noise, vibration, chemical pollutants, and so forth. Contradictory to this common previous medical belief are two other assumptions:

1. When we assume that stress in an organization is merely the same for all occupational groups (i.e., operations, staff, and management), we have to conclude that the differences in stress tolerance and stress reactions result exclusively from varying personality components. The individual differences in coping with stress would make it unnecessary to consider organizational factors or occupational conditions.

The older theories of human engineering put the right person in the right place and shaped the working conditions as much as possible to the hypothetical capacity of the individual worker. We know now that many more psychological factors are involved, especially when we consider the opposite; namely, that the type of work can shape the personality through identification with roles. Although we assume that work deals mainly with production and products, it is really related to changing relationships with other people. Within this framework the need for self-esteem, automomy, and self-actualization have a higher priority then money and social contact. As Herzberg (4) has pointed out repeatedly, the real satisfaction comes from work itself. Neither more money nor better fringe benefits nor improved working conditions necessarily increase motivation or happiness, although they are somewhat relevant as so-called "hygiene factors." However, motivation, job satisfaction and reduction of stress symptoms depend on feed-back mechanisms which confirm the individual self-concept as a reward.

Without going into details, our observations confirm that the most important changes (i.e., any crucial change in a person's work role--promotion, reward, and status; as well as demotion, being sidetracked, or transferred to a lower status job and less challenging assignments) usually occur during the ages of 35 to 45. The individual's basic sense of insecurity and inadequacy, the secret fear of failure, increases at the same time when he may also be confronted with disturbing psychosocial problems characteristis of the mid-life transition. Bennis says, "In any organization, leadership becomes the object of various fantasies, projections, devaluations, and idealizations." This apparent dependency upon leadership or defiance against leadership is based on irrational basic assumptions of a persistent family model that permits all kinds of highly unconscious transference repetitions. Most organizations are still structured as hierarchies that follow the family principle of authority, with linking-pin functions between the various levels.

2. Specific tasks, occupational positions, and the organizational environment produce different degrees of stress. Therefore, we would expect to find relevant differences in symptom rates among various occupational groups which are not related to personality factors.

Zaleznik et al. (6) has discussed four elements in an empirical study which elucidate specific connections between organizational structure and the rate of stress symptoms. He points out that the maturity effect, the vulnerability effect, the bureaucratic effect, and the power effect have a hypothetical relevance for the development of stress symptoms which differ among professional groups in organizations. The assumption that management is psychologically healthier and more mature than the operation and staff group has proven to be wrong; yet the vulnerability effect, based on stress reactions, caused by traumatic and unstable life histories could not explain the differences in stress reactions among the principal occupational groups. Differences instead among these three groups are the consequences of bureaucratic processes in organizations (7,8). Managers have some protection from simple and quantified measures of work performance and are "less anxious about evaluation and control," while staff and operations groups "experience considerable pressure, high accountability and uncertainty, and feel far more exposed to performance evaluation." (3). The fourth factor, power effect, hypothesizes that the ability to change organizational conditions through the possession of power to make relevant decisions, creates a different psychological environment with a greater tolerance for uncertainty and ambiguity.

The main stress factor in organizations--expressed as emotional distress, cardiovascular symptoms, gastrointestinal disorders, respiratory allergies, and medication use or abuse--seems to be based on the double bind of dependency needs versus dependency fears. Both factors are related to self-esteem and the need for acceptance. Thus, it comes as no surprise that during the crisis of mid-life transition with its crucial experience of self-confrontation and changing reality perception, it can become difficult "to keep one's private life from spilling over into one's public life and vice versa." (9) However, the conflict between individual needs and organizational needs leads to increasing stress reactions when the environment does not offer the expected gratification. We have seen many executives who tried to escape from family problems by increasing their work load up to more than seventy hours a week in order to avoid conflicts with their adolescent children. Stress symptoms reach a peak when the discrepancy between reward and need is perceived as being outside of the individual's control either in the occupational or in the family constellation. The individual type of stress symptoms may depend mainly on extra-organizational factors, the prevailing defense mechanisms, their flexibility and maturity, and the stages of psychological development throughout the life cycle. However, we would be mistaken if we try to define the causes for stress symptoms solely in the personality inventory without recognizing the specific conditions within the organizational structure.

A typical example which we see in numerous variations may elucidate the problem: A 43-year-old executive has reached his preset goal to become division manager and vice-president in a large corporation. He has been married for 15 years, his oldest child has reached adolescence, two other children are two years apart. His new position demands more travel and he increases his working time, thereby neglecting his family more and more and producing increased tensions and arguments at home. His wife is from a small town and feels inhibited and inferior at social events where she has to meet with the wives of the president and chairman-of-the-board. She expresses her frustration simply: "I married a school teacher and I am not prepared to deal with all these big wheels--I hate it." With the increasing alienation in marriage and the husband's secret concern about his diminishing libidinal capacity, he begins an extramarital affair, but feels guilty about it. His job performance declines and he faces a possible demotion. A six-year younger executive, his former subordinate and protegee, is delegated as his support. The vice-president begins to develop increasingly competitive feelings, sometimes slightly paranoid, with increasing resentment against the younger executive. His expectation of being involved in a new project and expansion is turned down, the project is assigned to another, older division head. The stress symptoms start with sleeplessness. He takes "downers" in the evening, vitamins and benzedrine and megavitamins in the morning. However, depression, moodiness, and irritability increase. Eight months after his promotion he has the first cardiovascular symptoms. Within the following two months he has a car accident, develops a drinking problem, his marriage is on the brink of divorce, the 14-year old daughter becomes involved in a youth gang and is arrested for possession of marijuana. Eleven months after his promotion he survives a heart attack that is primarily misdiagnosed as an intestinal disorder. A fringe benefit of the heart attack is his confrontation with reality which slows him down and leads to drastic changes in his life cycle. Although this sounds like a happy ending, he is now suffering from the increasing independence and emancipation of his wife.

We see similar histories regularly in seminars and individual executive consultations. Two quotes seem to be symptomatic: The question, "Who is the person you can talk to about your personal internal problems and concerns?" is typically answered, "I don't want to burden my wife. She does not understand my business problems and she wants to talk about her world when I come home--in fact, there is nobody I could really trust." One executive added, "...and when I want to talk to my dog, he runs away!" The most common complaint of 45% of executive wives is: "My husband never talks. I hear the things which happened from others weeks later at social meetings."

In the interest of time I shall not discuss typical stress symptoms of the mid-life transitional phase; although this period does not necessarily have to become a crisis. Of more importance is the growing number of female executives in an all-male world who are in isolated positions, surrounded by men who are either courteous in a stereotyped but phony way, or openly hostile and derogatory in their competition. Ulcers, gastrointestinal disorders and emotional distress prevail in these women as a result of common male prejudice.

Another quote that our profession has heard more often relative to the annual physical exam: "These doctors look into each orifice of my body. The only thing they are not interested in is what is going on in my head!" This statement should alert the occupational physician that he is often perceived as being in a functional part of the organization. Thus, to reveal personal problems or emotional distress to him is to potentially jeopardize one's career. As a consequence, early stress symptoms are either repressed or denied until later they become somatized and can be treated as a real illness.

There seems no doubt that the stress symptoms mentioned above influence performance and productivity in various degrees, but of more importance are new findings that the traditional hierarchical pyramid structure in an organization increases stress unnecessarily. Although many organizations are looking for remedies through training in relaxation and stress reduction methods, no gimmick can resolve the structural problem which causes stress symptoms as long as there is insufficient recognition of the psychological organizational conditions which either recognize or ignore the importance of positive feed-back, reassurance of self-esteem, and acceptance. The more we use medication as a remedy for organizational stress, the more we contribute to medication abuse and emotional distress as symptoms. Although the occupational physician will meet much serious resistance, within most organizations it is necessary to continuously underline the impact of structural dependencies which increase the feeling that the disparity between need and reward remains outside of one's control. Vocational training has thus far neglected using negotiating capacities to deal with those factors. The individual who develops the ability to continuously renegotiate the conditions of his psychological contracts through autoplastic, as well as alloplastic adaptations, seems less prone to stress reactions.

The average practices of performance evaluations are usually a narrow one-way street. Although various successful pilot studies with performance evaluations from above and below have demonstrated the better potential for reduced organizational stress (10,11), most organizations continue traditional patterns, refuting the subjective evaluation of their supervisors. The two-way performance evaluation may be possible by a new generation who has grown up under different psychological premises. We have just begun to study the meaning and psychosocial conditions of work; thus, it may be a long time before management will accept that coping with human beings is different from dealing with things and products. The future task of the occupational physician may be to study carefully the psychological factors of structural organizational stress conditions before their symptoms become observable in occupational groups. Highly technological societies tend to give lip service to the improvement in the quality of life, which raises serious doubts about how much we really care. Job performance depends on work satisfaction and content, which in turn are dependent on the self-concept: The hope for acceptance and the fear of rejection determine our self-esteem. Our future may depend on the ability to reestablish that human beings are different from things; they cannot be handled as objects without developing stress reactions.

We have observed that industry and business are continually searching for remedies through more training. Unfortunately, the larger part of such training concentrates on technological "nuts and bolts" courses. Thus, the statement of some of our participants is not surprising: "I have been to more than 30 or 40 training seminars; this is the first time I have learned something new about myself which helps me to better understand my relationship with others. It may be difficult and sometimes painful to change engrained patterns but I have got to do it." And one participant added, "...to save my life."

In closing, I want to return to Selye's opening statement which applies to most physicians in industry: "For my stress stems from the urge to help and not to judge."

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JOB STRESS AND WORK PERFORMANCE

Remaining Healthy in the Encounter with Stress

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Over the last twenty years, the medical literature has increasingly warned that stress has an etiological influence on illness (1,2). Both single, severe stresses and multiple, moderate stresses have been implicated in the onset of both severe and mild symptoms. Lately, this literature has permeated the popular communications media with the message that one should avoid stress in order to remain healthy. We are currently witnessing a dramatic movement toward stress avoidance, sometimes involving broad social shifts (e.g., attempts to return to a simpler life of preindustrial days), other times involving more individual shifts (such as meditation and increased reliance upon alcohol and drugs). So unrealistically extreme have attempts at stress avoidance become that one recent magazine article advocated staying off the Los Angeles freeway following the occurrence of stressful events for fear that one ~~will~~ have become accident-prone.

If the best advice that health maintenance professionals can give is to avoid stress, they have truly failed. The thrust of human energy and ingenuity is toward ever-increasing industrialization and urbanization; and that means mushrooming levels of change, demanding readjustment of living patterns. You will recognize the last part of this statement as the standard definition of stress: An event is stressful if it constitutes a change requiring readjustment of the persons experiencing it (3). As technological advance occurs, the continual production of new procedures, machines, and knowledge increase the complexities and opportunities of human life. As urbanization increases, the complexities and opportunities of human life also increase. So inherently stressful are

This paper, based on the doctoral dissertation of Doctor Kobasa, was presented by Doctor Maddi.

the changes constituting industrialization and urbanization, that to attempt to avoid them lest one become ill is to miss the promise of modernity. As if this failure to capitalize on opportunities were not enough, the attempt to avoid stress also renders the person and his society too vulnerable to the dangers of modernity. Such unwanted side-effects of industrialization and urbanization as pollution and crime must be dealt with, but they will not be cured by those persons who rush to avoid stress.

Is it possible to encounter (rather than avoid) stress and remain healthy? Surely everyone can recall hardy persons who withstand great stress without becoming ill. There is even an occasional person who has thrived on stress, becoming psychologically or physically healthier. Anecdotal observations of this sort provoked us to look more carefully at the basis for the generalization that stress leads to illness. We found that it is common for measures of stress and illness to show correlations of only .30, with standard deviations eight times those of the means. Consequently, there are bound to be many subjects who remain healthy despite severe stress experiences. That these hardy persons have not received much study is a serious flaw in the attempt to understand the effects of stress. We decided to study these hardy persons, hoping that they might constitute a model for the rest of us.

The next step was to theorize what might permit some persons to face stress without becoming ill. Three general factors seemed relevant: 1. constitution, 2. social support systems, and 3. personality. We decided to focus upon personality. In other words, "What personality dispositions decrease the debilitating effects of stress?" In hypothesizing answers to this question, we were guided most by the literature on coping (4), human development (5), and existential personality theory (6).

Our first hypothesis is that <u>among persons experiencing considerable stress, those who have a sense of commitment to (rather than alienation from) the various aspects of their lives will remain relatively healthy</u>. Committed persons possess the sense of purpose and active involvement that minimizes the threat of otherwise stressful events and provides a basis for continual grappling with problems and setbacks (6,7,8). By contrast, the alienated persons consider the world rather worthless and find insufficient value in stressful events to justify coping with them (9,10).

Our second hypothesis is that among persons experiencing considerable stress, those who remain relatively healthy believe that they have control over their lives (rather than feeling externally controlled). Persons who feel in control of their lives experience less threat in stressful life events because they believe in their ability to transform situations cognitively, and they respond flexibly enough to be effective (11). By contrast, persons who believe they are externally controlled are overwhelmed by stress because they feel powerless to cope, to influence, to transform, and are nihilistic in the face of the presumed power arrayed against them (6).

Our third hypothesis is that among persons experiencing considerable stress, those who seek novelty and challenge (rather than familiarity and security) will remain relatively healthy. Those who seek novelty and challenge have well explored their environment, know where to turn for resources in coping with stress, and are well practiced at self-imposed readjustment. Consequently, they can enjoy stress, be less debilitated by it, and recover from it more quickly (8,9,12). In contrast, those who seek security and familiarity will dislike stressful life events intensely and will be relatively unable to cope with them.

PROCEDURE

Subjects and Groups

Selected for the study were the management personnel of a large public utility situated in a major metropolitan area. All members of this pool were mailed standardized questionnaire measures of stressful life events (3) and symptomatology (13). These are the measures that have provided much of the evidence that stress increases the likelihood of illness; each measure includes a wide range of stress events and symptoms, and requires the subject to indicate the frequency and month of their occurrence over the previous three years. The rate of questionnaire return was 80%.

From these questionnaire results, two groups were constructed. Both were comparably high in stress; but where one was also high in illness, the other was low. Subjects, as well, were selected whose scores were well above or below the median of the distribution of stress and illness scores. Care was taken to insure that high stress scores preceded in time either high or low illness scores. The resulting High Stress/Low Illness and High Stress/High Illness groups were quite homogeneous and comparable on demographic characteristics that are thought to be conducive to successful coping (e.g., high income, good education, socially-valued employment, stable family situation).

Personality and Stress-Perception Measures

One hundred randomly selected subjects from each group were mailed standardized questionnaire measures of personality dispositions, including the Alienation Test (14), the Internal vs. External Locus of Control Scale (15), and a number of scales from the Personality Research Form (16) and the California Life Goals Evaluation Schedules (17). In addition, subjects were asked to give global ratings of the stressfulness of various areas of their lives (e.g., work, home). The rate of return for properly completed questionnaires was such that 75 High Stress/Low Illness and 86 High Stress/High Illness subjects were available for further study.

Data Analysis

In determining the personality and stress-perception differences between the High Stress/Low Illness and High Stress/ High Illness groups, reliance was placed on the discriminant function. This computation selects the best combination of variables at hand for explaining the differences between groups. In the computation, each variable appearing in the discriminant function is purified of the effects of the others and assigned a weight indicating its importance in explaining the group differences. Finally, an estimate is given of the amount of the total group difference accounted for by the discriminant function.

RESULTS

Descriptive Statistics for Entire Pool

Consistent with earlier work, the correlation we obtained between stress and illness in the entire pool of management personnel is

.24. The means and standard deviations of the stress and illness distributions are also comparable to those in other studies (399 and 162, resp., for stress; and 913 and 1155, resp, for illness).

Group Differences in Personality and Stress-Perception

Table 1. Variables which discriminate between the high stress/low illness and high stress/high illness groups

Variable	Standard Discriminant Coefficient
Alienation from Self	0.985
Vegetativeness	-0.990
Nihilism	0.316
Perception of Financial Stress	-0.336
Perception of Personal Stress	0.696
Perception of Interpersonal Stress	-0.476
Social Desirability	-0.236
Achievement	-0.452
Leadership	0.407
Interest in Novel Experiences	-0.274
Endurance	0.258

Table 1 shows the personality and stress-perception variables identified as important discriminators between the High Stress/Low Illness and High Stress/High Illness groups. There is support in these results for all three hypotheses stated earlier. Confirming the first hypothesis, the most potent discriminator shows that High Stress/High Illness subjects are more alienated from self than are High Stress/Low Illness subjects. Alienation involving work, interpersonal relations, social institutions, and family did not seem to make the same kind of difference. Confirming the second hypothesis are several discriminators: High Stress/Low Illness subjects are less vegetative and nihilistic than are High Stress/High Illness subjects, indicating their belief that one can control the events of one's existence. Confirming the third hypothesis, the High Stress/Low Illness subjects are more interested in novel experiences; at the same time, they are more oriented toward achievement and show more endurance than do the High Stress/High Illness subjects. These variables signify the importance of perception of change as an opportunity and a challenge rather than a threat.

In response to stress-perception questions, High Stress/Low Illness subjects perceived less threat in personal, financial and interpersonal areas than did High Stress/High Illness subjects. It is important to recognize that these subjective perceptions constitute different data than the stress scores upon which subjects were initially assigned to groups. These latter stress scores represent objective or consensual indicators of the stressfulness of subject's lives. Thus, for the same objective levels of stress, subjects who do not become ill feel less threatened subjectively than subjects who do become ill. These findings are consistent with those more directly testing the hypotheses.

The only discriminator which seemingly does not fit shows that High Stress/Low Illness subjects are higher in the wish to appear socially desirable than are High Stress/High Illness subjects. This wish is often regarded as a sign of conventionality and passivity. But, as is common with business persons, both groups were extremely high on this variable. Extremely high scores probably indicate ambition and high standards more than conventionality *per se*. Thus, on second thought, this finding is not inconsistent with the rest.

The discriminant function identified accounts for 74% of the total variance of the differences between the groups, and as such, is highly significant (Wilks' lambda = .57; $p < .001$).

DISCUSSION

This study provides a basis for understanding how persons can willingly or unwillingly encounter great stress and remain healthy One must be aware of and involved with oneself, believe that one can control and transform the events of one's experience, and perceive change as an opportunity and challenge rather than a threat. The longer one has this overall orientation, the greater will be his accumulated skills and resources for dealing with stress. When stress actually occurs to such a person, he or she will be energized and exhilarated rather than debilitated and worried.

However, additional study is needed before these results can be put into practice. As in many studies of the effects of stress, ours collected stress, illness, and personality data at approximately the same point in time. It is difficult, therefore, to make any definite causal inferences. All three variables might well be influencing each other. One needs to collect stress and personality data at "time one" and then see if their interaction will predict illness at "time two"; we are currently collecting data for such a prospective study. This study will also supplement questionnaire responses with interviews to cover both the present and past. Should the results of this prospective study confirm what we have reported here, there will be a solid empirical basis for putting the notions discussed here into practice.

Consider the implications for occupational medicine. With mounting economic, political, and consumer pressures, industries and businesses place ever-increasing amounts of stress upon employees at all levels of the organizational hierarchy. As a culture, we are increasingly unwilling to believe that stress at work is necessary. If there is much stress, then the business or industry is regarded as failing in its responsibility to employees. This cultural trend toward rest and relaxation as an ideal is supported by the communications media who regard stress as a cause of illness. The occupational physician is confronted more and more with angry and frightened employees who attempt to enlist his aid in the avoidance of stress. There is pressure on labor unions and employers to increase job protection and curb changes that impact on workers. At the same time, employees are becoming less involved in their work, putting their energies and talents into avocations. Alcohol and drug use are still increasing. All of these movements can be seen as avoidance of stress. What is so unrealistic is that there are also societal forces which are increasing stress on industries and businesses, and inevitably on their employees.

With the results of this study, the occupational physician is given another option in his treatment of employees. The physician does not have to participate in unrealistic attempts to avoid inevitable stresses. Rather, he can counsel the employees that stresses must not necessarily lead to discomfort and illness. The personality dispositions and perceptions of stress associated with the hardy, highly stressed individual can be shared with other employees. This knowledge alone may help persons to be less frightened and threatened. It should also be possible to encourage workers to identify with these hardy individuals.

Other employees may be so preoccupied with security and their inability to cope with stress that exhortation alone will not be enough. In these cases, psychotherapy would seem indicated. But one must recommend with care the kind of therapy that is responsive to the problem. Practices that specialize in psychotherapy for stress management are springing up like weeds. Most of them conclude that stress leads to illness, and teach the patient various techniques of stress avoidance, from relaxation to meditation. Our findings, on the other hand, call for the kind of psychotherapy that has nothing to do with stress-avoidance. Instead, it seeks to transform the patient's outlook and actions such that he is:

- highly aware of and involved with his own internal thoughts and feelings;
- willing and able to influence and transform events of his experience through the decision-making process;
- believes change to be inevitable and an opportunity for growth.

This therapy assumes that life best led is a strenuous process, and that fulfillment of human capabilities is ultimately more satisfying than is rest, leisure, and easy security. We call it existential psychotherapy, and regard it as a good preparation for modern times.

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JOB STRESS AND WORK PERFORMANCE

The Stress of Relocation - Recognition and Prevention

James E. Kelsey, MD

My discussion will deal with the stress of company-initiated relocation. Within these confines we must agree to some basic assumptions regarding stress, i.e., emotional stress. Stress is a threat, a pressure, or a force acting on the individual. It can come from outside or within the organism. We all live with stress, and we all perceive it differently and adapt to it in different ways.

We live in a stress-producing society. Entertainment is frequently violent; our transportation is violent and stressful; our instant news accents violence, particularly on television. The carnage of the highway and battlefield is projected into our living rooms and bedrooms in color and grisly detail. So who can deny the reality of these sources of stress?

Society needs stresses to keep its institutions operational. Without the stresses of needs, desires, and ambitions, we would not enjoy the social progress, the educational challenges, and the standard of living that we have attained. A simple rule for interpreting stress is that stress is a positive or constructive force if you are handling "it," rather than "it" handling you. When stress is excessive or the individual is unable to adapt, it may cause anxiety and fear. It may cause symptoms and physical disease.

Stress is also present in our places of work. Employees arrive at work fatigued by their over-programmed social lives and the demands of late-night TV. They are over-stimulated by expectations from the "Play..." magazines for super-sexual performance, leading to stress and fatigue. They are stressed by the rigors of travel to and from work and are further stressed by the work environment itself. It is an additive situation.

When assessing stress in a business setting, it is necessary to understand and accept the need in some employees to succeed. This self-induced stress may be excessive; and although it may be a valuable asset to the corporation that views such employees as "stars" or high achievers, this self-stressed employee may be very destructive at home or in his or her role as spouse and parent.

One of the occupational stresses that the Northwestern Bell Telephone Company has been studying is the stress associated with company initiated moving. Moving families from one city to another, or even within the same city, can be an excessively stressful experience for all members of the family. Relocations in our company and in other large corporations usually are tied directly to a promotion or are aimed at providing a different management experience that can later lead to a promotion. Because of this implied coercion, many ambitious and aggressive managers are reluctant to consider any alternatives to the move. So driving are their ambitions that they are frequently reluctant to discuss the move with the spouse and children. They fail to involve the members of the family in the decision. They fail to consider the options or alternatives.

Over the last four years we have researched what is being done around the country to help families with problems of relocation. Most large corporations go to great trouble and expense to provide assistance in the selling of the home and compensation for all moving expenses. Some even finance exploratory trips for the employee and spouse to aid in the selection of the new home at the new location. These mechanics of moving are all well covered. However, our research has found few examples that aid in the emotional sphere--where most of the problems focus. There is one large moving corporation that has sponsored symposia on the effects of relocation on members of the family (1,2,3). Some corporations that have extensive international relocations, have programs to help the families adjust to the marked shock of cultural change. But it is safe to conclude that the large share of corporations do little or nothing to prepare all family members for the emotional assault and stressful consequences of the move.

From the corporate point of view, the usual but illogical attitude is that the employee's family will enthusiastically cooperate and support the move because it means an enhanced career and greater rewards for the breadwinner. If the personnel department (which is usually in charge of the relocation details) and the employee's immediate boss use good management practices, they will share with the employee their plans for his or her future and will explain how the new job assignment will, by providing needed experience, aid in his managerial development. This is sometimes known as "career pathing." If the employee shares this "career pathing" with his spouse and family, then the surprise element is eliminated, and understanding and acceptance are made somewhat easier. If family members accept and adjust to the move, the stress is controlled. To be effective, the philosophy of "career pathing" and the commitment to its effective use must begin at the top of the organization and extend throughout the middle levels of management.

In Northwestern Bell Telephone Company-- which covers both Dakotas, Nebraska, Iowa, and Minnesota--corporate-induced moves are necessary. Management development through a wide variety of experiences is achieved by transferring high potential employees to locations in the Bell system. During the early 1970's, Northwestern Bell moved approximately 650 employees and their families each year. In 1976, we moved 485 families. On the other hand, it is almost impossible to record how many employees turned down the opportunity to relocate. Many times the supervisor is informally aware that the employee will not move and the offer is, therefore, never tendered. We must accept the fact that we are going to continue to initiate employee family moves; thus, we must help these employees and their families deal with the associated emotional stress.

For a corporate family going into an established neighborhood, the chances are good that the neighbors will reach out and try to make the new family feel part of the neighborhood. If there are children of school age, the parents can bridge social barriers through the children and get to know people at various levels in the community. However, if this "new" family moves again in another two or three years, the pain of leaving is also borne by the neighbors who are left behind. After several experiences such as this, the fixed neighbors will be less warm and open to other corporate families who move in. The neighbors may sense that this "tour of duty" will be as short as it was for the previous family. Thus, a mechanism of adaptation, in this instance the making of new friends, is lost.

In Battle Creek, Michigan, at the Lakeview High School, there is a two-year program, "The Host Program" (4), which was started by a teacher in the department of sociology. Volunteer students are trained to be school and community hosts to new students coming into the community and the high school. These hosts acquaint new students with dress styles and other peer behavior patterns--where the kids "hang out," what they usually wear and how they talk. This helps the new student understand and adapt to peer group functions. With conformity as important as it is at the adolescent level, this program is solving some of the stresses of moving in Battle Creek, Michigan. As one of the new students said, "My host was somebody I could call when I didn't know anyone to call."

Older children who have a sport or talent in which they excel can bridge without difficulty the move from one city to another or one school to another. Athletic credentials, experience as a cheer leader, or participation in some other student activity that can be carried over to the new institution provide an excellent opportunity for meeting new people. Unfortunately, scholarship and intellectual interests in the sciences or classics do not provide an effective bridge for social interaction and new school friends.

Many employees have said that the move must come as soon as possible once the announcement about the transfer has been made. For the employee may be left in a disrupted organizational unit that is waiting for his replacement. The announcement has been heralded and he is anxious to meet his new challenge. The family, meanwhile, watches their community foundations crumble and is perturbed with the idea of losing close friends. There is usually no stimulating challenge for them in the new community. There are no tangible rewards--they begin again at the space marked "Go."

As families get older, the children leave home; the parents do not have the entree into a neighborhood that children living at home provide. Some gynecologists have referred to the depression at this stage of life as the "empty nest" syndrome. The mother who has built her life around the children has also reached middle age with its menopausal upheaval. If another corporate relocation is added to this stressful state, it will not be unusual for clinical symptoms and negative behavior patterns, including drug dependence, hostility, and divorce to appear.

Figure 1/ diagrams the forces at work in a typical family relocation. Above the balance beam are the positive and negative factors which influence the decision. One may assume that a positive decision will lead to a satisfactory move; whereas, a decision based on negative factors will lead to an unsatisfactory move either for the employee, the family, or the corporation. The fulcrum represents the "decision threshold," and factors are shown which influence its position under the beam. Obviously, the family who is willing to take the risk and desires a change in environment will push the threshold in a positive direction. A family with negative attitudes will force the decision threshold in a negative direction. Negative counsel by the boss or friends might also move the threshold in a negative direction. The family with positive strengths and relationships will likewise influence the decision threshold in a positive direction.

PERSONAL COUNSELING SERVICE

Northwestern Bell has developed several programs to help our employees deal with their emotional stresses and anxieties. There is an active personal counseling service in the Iowa and Nebraska facilities. Each year five to six percent of our employee families voluntarily contact the Personal Counselor for help (5); some of them have stress from the relocation per se, while others have family problems that can prevent a successful adjustment to a company-induced move.

FAMILY SYNERGY

About $2\frac{1}{2}$ years ago, we started a series of workshops using faculty members of the University of Nebraska at Lincoln (6). These workshops were begun on an exploratory basis to determine the nature and extent of the stress of relocation, and if this experience could help families. Some of the workshops included husband and wife, while others included both parents and children above age 10. After involving sixty families, it was decided to modify the format to include more than the stress of relocation. The workshops are now called "Family Synergy."

The Family Synergy Workshops help participants understand techniques that they can use to solve problems and relieve stress. When the group has become comfortable and has acquired group integrity,

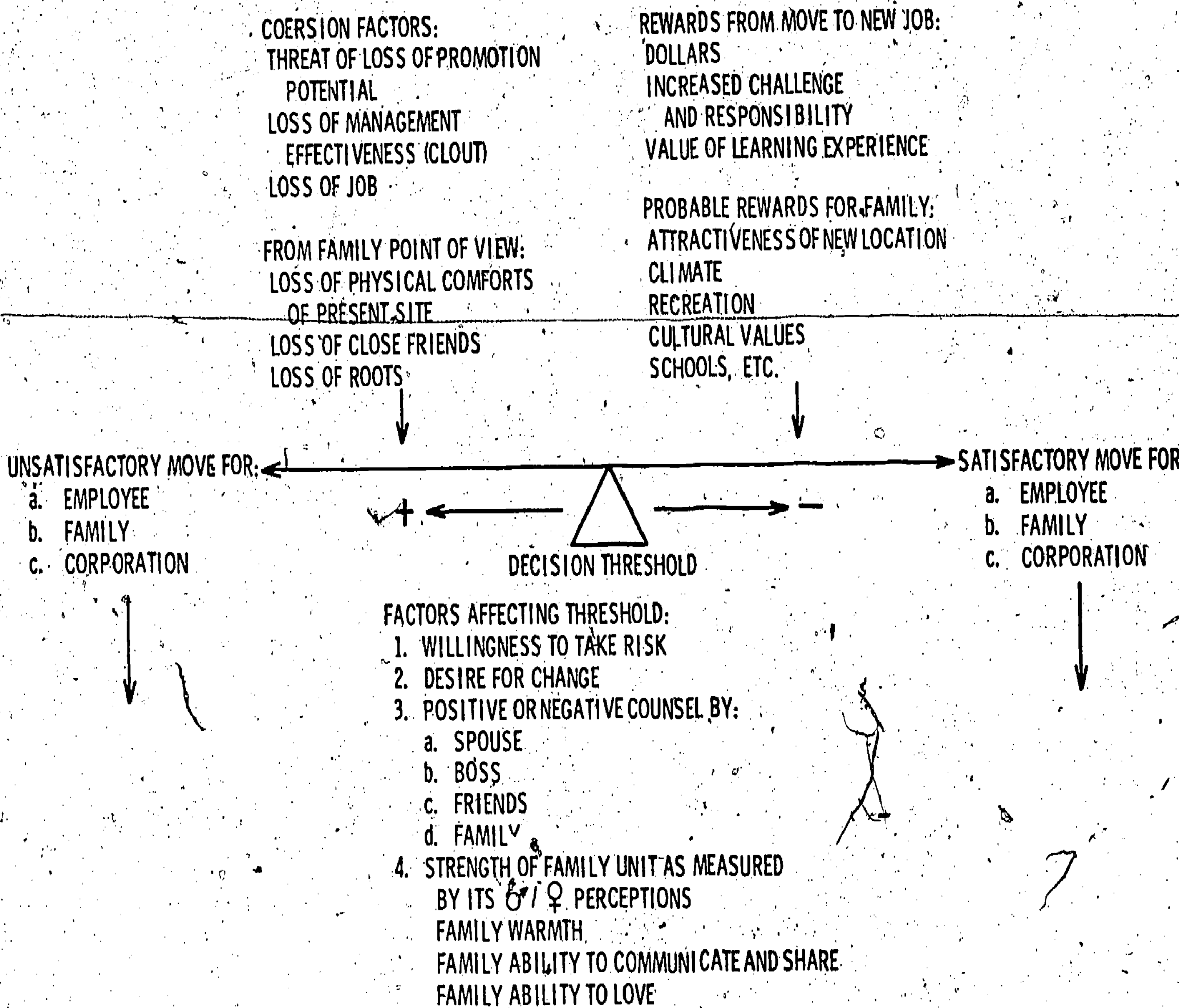

Figure 1. Shows forces affecting the decision making in a corporate relocation. The balance beam moving in a counter clockwise rotation would be evidence of an unsatisfactory move; moving in a clockwise rotation would be a satisfactory move.

its members learn by sharing experiences of how others solve problems.

One measurement that has come out of this experience is the "stress ~~scale" using the Osgood technique(7) for semantic differential.~~ Participants are asked to rate a series of sixteen keywords and phrases from one to seven. In almost every instance, words and phrases associated with relocation are given a high rating.

One of the challenges associated with the Family Synergy Workshops has been to keep these educational experiences from being threatening to the lower and middle level management families. Since the workshops are held during off-work hours on a voluntary basis, how do we keep them from being viewed as an imposition? How do you prevent supervisors from forcing families to attend? We have overcome these hurdles by having the invitations originate with the Medical Department, thus assuring the employee that the experience is voluntary.

MALE/FEMALE AWARENESS WORKSHOP

Northwestern Bell's two other programs, though not aimed directly at improving and supporting families of multiple inter-city moves, will strengthen family relationships and help families adjust to relocation.

One is titled the Male/Female Awareness Workshop. This is a very effective voluntary program that examines the various forms that sexism takes in a large corporation or community (8). It is a 3½ day experience for 24 males and 24 females, and does not include spouses or other family members. It's goal is to help our employees understand the nature of institutional sexism. Participants also learn a great deal about their personal feelings and attitudes toward the opposite sex. For the first time in their lives, some participants understand what their sexist attitudes are. For many, this is quite a revelation! A husband who does not understand the socialization process his wife must stumble through in trying to understand her own needs for achievement and personal growth often will not be able to help her in a new community setting. A husband who understands our community institutions may see a move as a way for his wife to break away from a certain life-style which she may not want, deserve, or need. Relocation would thus be a positive move with less personal stress for her and less for the rest of the family.

When both husband and wife are employed in stimulating careers, it is necessary that they understand the mutual respect and honesty which healthy male/female relationships require. If so, their moves will be far less destructive than the usual cases of this type--the man demands his wife place her role second to his and give up her career.

MANAGEMENT COUPLES PROGRAM

The Management Couples Program is a unique workshop in our experience because it involves upper-level managers and their spouses in a controlled setting for four days and nights (9). At present, only one in five wives of upper-level managers is employed. This ratio may ultimately change, but at present the husband is at work and the wife is at home in most of these families. Each workshop has 12 to 15 couples who attend on a voluntary basis. The program develops group integrity and couple solidarity; couples are then placed in a situation where they cannot ignore issues--they must examine and understand the assumptions upon which they base their marriage and careers. The spouse at this time is expected to develop a self-awareness by asking the questions, "What do I want of my life? How do I get there without manipulating others?" The spouse as wife and mother is supported with the philosophy "It's O.K. to be what is O.K. with you." The group learns that there is more than one male and female role model. They learn about the relationships between the employee and the spouse to the business. By questioning their basic assumptions, which may have changed over the years to where they are now false, the partners see each other in a new and more honest light. They are able to develop understanding, empathy, and more realistic common goals. There is an effective measure of feedback, both at the end of the workshop and after several months. The company has been asked repeatedly not to take spouses for granted.

CONCLUSIONS AND RECOMMENDATIONS

1. Business organizations, large and small, impose excessive ~~stresses, real or imagined, on their employees at all~~ levels. The manager who is able to understand these stresses and their effect on the family unit, and who is willing to take action to relieve the stresses, will have a stronger and better adjusted work force than the manager who does not.

   To understand the effect of business-related stress on employee families requires management, at all levels, to thoroughly understand the fundamental techniques of communication. Good communication can make the difference between authority that is stress-producing and authority that generates respect and allegiance. For these reasons, communication courses should be required for all levels of management.

2. For alleviating stress at the workplace, particularly the stress of a company-initiated relocation, there should be a clear understanding between the boss, employee, and spouse early in the career of a high potential employee, that a series of moves may be offered by the company. The spouse must understand the reasons for the moves, the rewards associated with the moves, and the timing.

   Work and family conditions change. The basic marriage assumptions are also modified and changed by children, financial problems, and the health of the family members. People remember selectively. Frequently, they forget, unless there is reinforcement, some of the unpleasant information they have been told. It is in this framework that "career pathing" is of value. "Career pathing" requires that the personnel department and the employee's supervisor analyze the strengths and weaknesses of the individual under consideration; and then, employee and supervisor together plan the route by which goals will be attained. "Career pathing" falls down when middle management fails to make careful application of this modality. Such a program requires time and study on the part of the supervisor, guidance from the personnel department and repeated discussions with the employee. Top management must reflect their commitment to the career plan philosophy and its execution.

3. The future will have increasing numbers of husband/wife teams in the labor market. Middle and upper management executive wives may not be willing to assume the role of the passive homemaker. The corporate entity cannot be responsible for resolving marital disputes about whose career is the more important. But the company can provide educational experiences that enable corporate families to listen and understand each other and resolve their differences. By way of encouragement, the company should recognize and reward both husband and wife at the time of the company transfer.

4. A single-purpose family is one with a single career goal and pathway. But it is becoming increasingly recognized that women make excellent professionals and managers, and are high achievers with high energy levels; therefore, in the future there will be fewer single-purpose families in management. Corporate officers and managers at all levels must recognize this and plan in advance.

   It is suggested that:

   a. The corporation develop new and receptive attitudes toward nepotism. With both husband and wife working for the same company, a corporate move should be easier to facilitate. The husband and wife could be employed and managed as separate individuals, but moved as part of a family unit.

   b. For those dual-purpose families (where both husband and wife have individual career roles and do not work for the same corporation), there could be a series of inter-industry agreements that would effect relocation of both career people to the same geographic area.

c. Where a satisfactory transfer arrangement cannot be worked out for the spouse, a system of incentive rewards could be provided. These incentives could be in a form of a direct financial payment, underwriting of educational opportunities in the new city, or even an employment service to enable re-employment of the spouse.

d. Corporations should recognize the need for and give support to an employee organization that has a "welcome aboard" service. Volunteer groups would be trained to act as hosts to the new families. A teenage organization, coordinated with the high schools and junior high schools, would recruit peers to assist the relocated students.

e. A new corporate attitude and policy should be instituted to enhance management development without a transfer of the family. For example,
   1. brief tours of duty at distant sites,
   2. management development within the same work location to the greatest extent possible,
   3. remove all stigma from any refusal to transfer and move only those families who genuinely desire to do so.

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ROLE OF INDUSTRY IN PREVENTIVE CARDIOLOGY

Introduction

James A. Schoenberger, MD

Before we can define the role of industry in preventive cardiology, we need to develop a case for the preventability of cardiac disease. My remarks, as well as those of the other panel members, will be directed only toward the prevention of coronary heart disease, the major cause of death in the United States, a disease which has assumed epidemic proportions here, as well as in other affluent, industrialized countries.

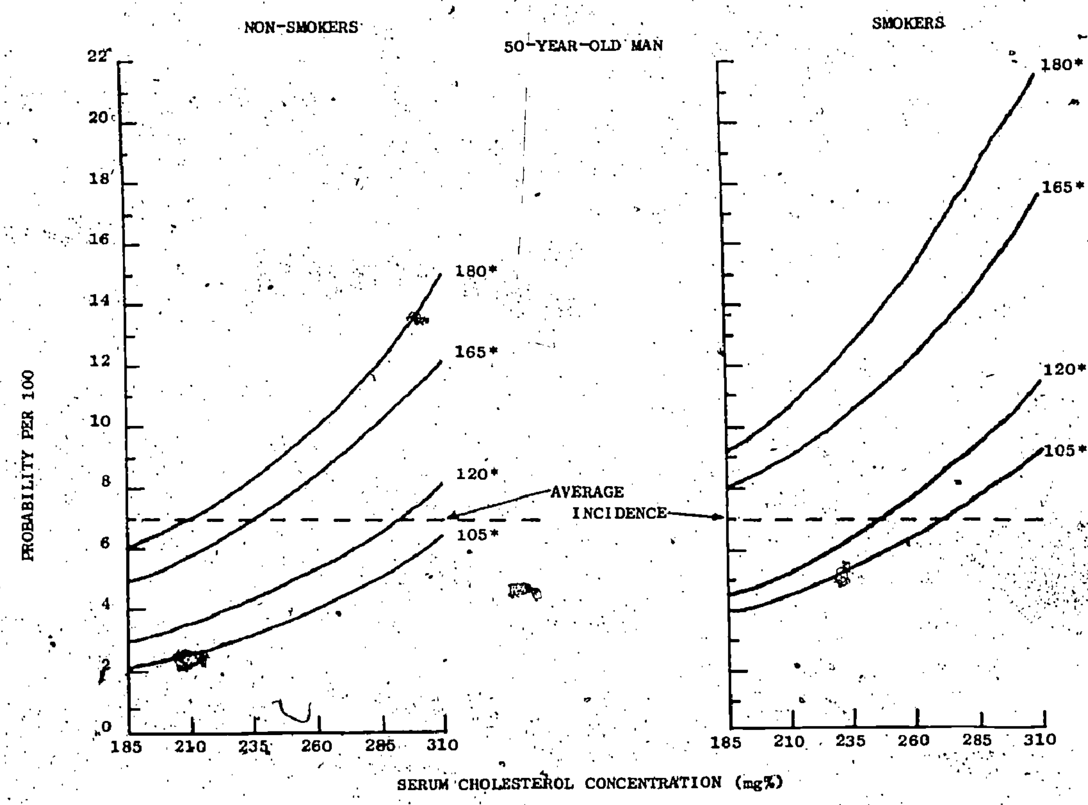
Years of epidemiologic research have demonstrated, both in the U.S. and throughout the world, that certain characteristics are associated with the future development of coronary heart disease. These risk factors explain most, but not all, of the variance of coronary heart disease in populations and are extremely useful in identifying the high risk individual. Even though a direct cause and effect relationship between risk factors and atherosclerosis is still partially inferrential, the concept that changes in risk status will alter the subsequent course of the disease form the basis for the field of preventive cardiology.

Although many characteristics have been shown to be related to increased risk, and probably many yet remain to be identified, only those which are capable of modification constitute a valid approach to intervention. Those which most clearly are related to risk, the so-called major risk factors, are the high fat, high cholesterol atherogenic U.S. diet, cigarette smoking, and hypertension. The inter-relationships between these major risk factors and the development of coronary heart disease are shown in Figure 1.

These data from Framingham show the inter-relationships between the three risk factors for a 50-year-old male. It can be seen that risk of coronary disease is a resultant of an inter-play of all three, that this risk can rise significantly with modest elevations of two or more risk factors and that most of us are far above ideal

FIGURE 1

PROBABILITY OF A MAN DEVELOPING CORONARY HEART DISEASE IN SIX YEARS BY AGE, CIGARETTE SMOKING AND CHOLESTEROL AT SPECIFIED LEVELS OF BLOOD PRESSURE AND IN THE ABSENCE OF LEFT VENTRICULAR HYPERTROPHY AND GLUCOSE INTOLERANCE THE FRAMINGHAM STUDY



*Systolic Blood Pressure (mm Hg)

TABLE 2

PERCENT CHANGE IN HEART ATTACK DEATH RATES - U.S., 1968-75 BY AGE, SEX AND RACE

Age Group	White		Non-White	
	Male	Female	Male	Female
35-44	-23.6	-21.5	-27.7	-42.7
45-54	-17.8	-16.6	-21.2	-32.5
55-64	-17.6	-18.5	-21.7	-27.3
65-74	-17.8	-23.7	-19.3	-22.7

Note: Based on death rates per 100,000 population, 8th Revision ICDA Codes 410-413.

Mortality Source: Vital Statistics of U.S.
1968 - Vol. II, Part A
1975 - Personal Communication with Mortality Statistics Branch in Wash., D.C.

Population Source: Current Population Reports
1968 - CPR Series P-25, #519, Table 2
1975 - CPR Series P-25, #643, Table 2

risk by virtue of the widespread prevalence of risk factors in the U.S. The same data are shown in Table 1. This table from the Coronary Risk Handbook, prepared by the American Heart Association, contains similar tables for men from 35 to 65 and for women from 45 to 65. ~~The Handbook is invaluable in the consulting room~~ for the physician and future coronary victim alike.

If you will accept that we can identify the high risk individual by simple measures, what is the evidence that we can change the future by timely intervention? This has been amply demonstrated in the animal model, but evidence in the human is hard to come by. No definitive study has yet shown that a multiple risk factor intervention approach will prevent coronary heart disease. A large clinical trial, the Multiple Risk Factor Intervention Trial (MRFIT), designed to answer this question is underway, but the results of the trial are still five years away.

Meanwhile, most of us would agree that prudent measures, not harmful in and of themselves, such as changes in diet, cessation of smoking, treatment of hypertension, prescription of exercise, and reduction of excess weight have a potential benefit which justifies their recommendation now to the individual patient and even to the population at large before the final evidence is in.

I submit to you that the American public has already gotten the message and the single most important breakthrough in modern medicine is occurring under our very eyes. Table 2 shows what has happened in just the last seven years. Coronary heart disease is going down significantly for all age, sex, and race groups! This downward trend is the first breakthrough in the last 25 or more years.

Why this has happened is still a matter of speculation and debate. To me, the reasons seem clear. The consumption of animal fats and mean cholesterol has been going down steadily since the mid sixties. Thirty million Americans, mostly middle aged and male, have quit smoking. Cigarettes contain less tar and nicotine and produce less carbon monoxide. In just the last few years, more and more hypertensives have been identified and placed under effective treatment. I am prepared to accept that the dramatic downturn in the incidence of coronary heart disease is probably related to these major changes in the eating and smoking habits of the public.

TABLE 1

PREVALENCE OF HYPERTENSION IN %

1967 - 1973

Sex and Race	Age in Years 18-24	25-34	34-44	45-54	55-64	All
White men	9.3	11.3	17.5	29.1	40.1	21.1
Black men	7.4	16.3	22.5	40.0	50.8	23.3
White women	2.2	4.0	10.5	22.7	35.7	16.2
Black women	2.1	6.0	18.2	38.0	46.6	10.9
All	4.7	9.4	15.6	26.8	38.4	18.7

Hypertension: Systolic blood pressure ≥ 160 mm Hg or diastolic blood pressure ≥ 95 mm Hg or current medical treatment for hypertension

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As physicians I feel we have an obligation to the public to bring these facts to the attention of our patients and to support, to the fullest, public health measures aimed at the reduction of saturated fat in the American diet and the elimination of cigarette smoking.

What Does All of This Have to do With Industry?
First, it should be obvious that a healthy work-force is probably the most valuable asset of any industry. Second, although I cannot document this, I believe that prevention can be cost effective. The costs of hiring and training new employees, the costs of health care insurance, the costs of disability insurance, the costs of disability and retirement benefits, the costs of death benefits are all considerable and, taken together, constitute a large part of the cost of doing business in America today. Any sensible business man ought to have more than a passing interest in reduction of these costs.

If, as I have shown, coronary heart disease is not inevitable, and the means for a prudent approach to prevention are at hand, this conference is very timely. It is time for industry to take a piece of the action. For too long, industry has been preoccupied with industrial accidents. These problems have largely been contained. The surface has not yet been scratched in industry's role at keeping workers healthy and free of heart disease. We need to determine what the costs of doing this will be. If they prove to be less than the costs of uncontrolled illness, it is easy to predict that, out of enlightened self interest, industry will move into the area of preventive cardiology.

Today we will discuss some measures which can be taken to control the risk factors in the industrial setting. At the outset it must be pointed out that there are great constraints against industry taking steps in those areas which involve personal habits of life style and confidentiality of personal health data. Whether industry can successfully influence how employees live in a favorable way is not known. Since there is an economic motive to attempt this, we will be exploring in this discussion how human behavior can be changed; for, in the final analysis, rampant coronary heart disease is an expression of aberrant human behavior- - eating, for whatever reason, the wrong diet, smoking cigarettes, and probably, to a great extent, developing high blood pressure.

The industrial site as a locus for intervention is suggested mainly because industry has a vested interest in conserving the health of workers and because nowhere else are workers concentrated so conveniently in time and place.

I shall now describe the potential for controlling hypertension at the work site. Then Dr. Agras will treat the problems of behavior modification regarding smoking and diet. Dr. Dedmon will tell us about new developments in the field of exercise programs at the work site. Finally, Dr. Stason will subject our speculations to the harsh light of cost effective analysis. Thus we may hope to sift out what is of proven benefit, how hard it will be to achieve, how much it will cost, and what it will be worth.

CONTROL OF HYPERTENSION IN INDUSTRY

A categorical approach to coronary prevention is indicated because we have the most experience in the area of hypertension. At one extreme, Dr. Alderman, working under union auspices, showed that it was possible to control a great majority of hypertensive workers who were seen on company time and received free drugs and medical care. This ideal approach is not always possible in this less than perfect world. I would like to describe the experiences in Chicago, a more typical situation, where my colleagues, Drs. Stamler and Ahekelle, and I have screened over 40,000 men and women at the work site. A great deal was learned from this experience and that knowledge should help to shape future programs, either single phase hypertension programs or multiphase comprehensive health programs.

In the first place, participation by the worker, in the American tradition, must be voluntary. Programs carried out on the worker's own time are less successful in recruitment of participants. Participation is jeopardized by concerns over the confidentiality of the findings. If the employee feels that the knowledge of his hypertension can be used to his disadvantage by management he would probably rather not know what his blood pressure is. The best way to circumvent this fear is to involve unions early in the planning phases of a program so that the issue of confidentiality can be dealt with. Finally, management also has fears regarding the carrying out of screening programs on company time. What is offered first as a good will gesture, however self-enlightened, becomes the basis for a perpetual fringe benefit for next year's contract at the negotiating table.

Because of these many considerations, the volunteer rate for screening programs varies widely. An average figure of 50-70% participation is realistic; but, when it is carried out under unfavorable auspices, such as poor pre-screening publicity and on individual time, the rate can be much lower. Obviously, the higher the rate the greater the potential impact of the program. As in other matters, the easier it is made for him to do, the more likely the worker is to participate.

Although the percentage of undetected hypertensives is reported to be falling, our data from Chicago for the years 1967-1973 would suggest that hypertension is very much a public health problem. On Table 3 the prevalence of hypertension, defined as a BP of ≥ 160 and/or 95 mm Hg is shown for various age, sex, and race groups. A problem which affects 18.7% of the working population is certainly a major one. Except for the younger ages, there is the usual preponderance in blacks and all groups show an ominous rise in prevalence with age to an average of 38.4% in the group 55-64.

The entire justification for screening is illustrated in Table 4. for age 25-44 and 45-64. Not only is hypertension common, but the majority of victims, men and women, black and white, either are unaware of it, are not getting any treatment if they do know of it, or are still hypertensive due to inadequate treatment. Although our data do not suggest that the Veterans Administration Studies demonstrating the value of treatment have had any impact on this situation, the National High Blood Pressure Education Program of the National Heart Lung and Blood Institute (NHLBI) claims that mass public and professional education is beginning to turn the corner on control of hypertension. Table 5 shows that the most recent studies would seem to indicate a favorable trend in detected and adequately treated hypertension. Evidence from another source - the Chec program - would support this conclusion. From this I infer that, although the public is better informed about hypertension, for properly selected target groups - such as younger individuals, particularly blacks - screening is still a necessary component of a hypertension control program.

In our program, individuals with blood pressure above the cutpoints established were referred to private medical care through a series of computer generated letters sent at monthly intervals. Compliance with the advice was signaled by the return of a postcard indicating

TABLE 3

THERAPEUTIC STATUS OF HYPERTENSIVES IN %

Age 25-44

1967 - 1973

Status	MEN		WOMEN		All
	White	Black	White	Black	
No prior diagnosis	67.6	69.7	56.6	49.2	64.8
Prior diagnosis, not treated	21.4	20.0	19.8	20.2	21.0
Treated, but pressure high	5.5	7.7	10.8	12.9	7.0
Treated and pressure not high	5.5	2.6	12.8	17.7	7.2

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TABLE 4

THERAPEUTIC STATUS OF HYPERTENSIVES IN %

Age 45-64

1967 - 1973

Status	MEN		WOMEN		All
	White	Black	White	Black	
No prior diagnosis	58.8	62.9	47.0	35.7	59.2
Prior diagnosis, not treated	17.3	18.0	17.9	18.8	19.3
Treated, but pressure high	14.9	12.6	17.5	23.2	11.6
Treated and pressure not high	9.0	6.6	17.6	22.3	9.9

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TABLE 5

PREVALENCE OF HYPERTENSION AND TREATMENT
FOR HYPERTENSION AT SCREEN I AND SCREEN II IN %

1967 - 1973

	Age ≤ 44 years (N = 2456)			Age ≥ 45 years (N = 1925)		
	Screen I	Screen II	P Value	Screen I	Screen II	P Value
Systolic BP ≥ 160	6.6	9.7	<0.01	17.8	28.9	<0.01
Diastolic BP > 95	6.9	9.0	0.01	15.3	19.4	<0.01
Systolic HP ≥ 160 or Diastolic BP ≥ 95	10.4	13.6	<0.01	22.5	33.1	<0.01
Treatment for Hypertension	1.5	2.5	<0.01	9.4	12.5	<0.01

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the participant had seen the doctor. The results were always less than could be hoped for, especially in the younger ages. Thus, even before we deal with the problem of what the doctor will or will not do, we must accept that most screening programs, reaching a participatory rate of 70% and a successful referral rate of 60% will have a potential influence on much less than half of the individuals at risk. Is half a loaf better than none?

The impact of screening and referral programs cannot be evaluated solely by the numbers going through the process. The program should be designed to identify individuals with high blood pressure and get them under sustained, effective treatment.

We studied this by going back one to three years later to rescreen those same individuals to see what had happened. Table 6 shows that the prevalence of hypertension had gone up significantly. This discouraging finding may be in part attributed to the incidence of new cases, but the rather modest increase in the percentage of individuals on treatment at both age strata would suggest that the screening and referral process used by us had not truly been effective at inducing any lasting benefit. Most of the rise was in systolic blood pressure, confirming the well known fact that systolic blood pressure rises with age in industrialized countries.

CONCLUSION

These results might discourage further effort in the screening-referral method of dealing with the hypertension problem. But since there is such a large reservoir of undiagnosed and untreated hypertensions in the general population, and the situation is undoubtedly worse in the lower economic strata and the younger age groups, we cannot yet abandon this approach to correctly select target groups in the general population.

The methods need refinement and strengthening. We need to enhance participation in these programs, to improve successful follow-up contact for medical evaluation and treatment, more aggressive and effective intervention by the medical care system, and long term adherence by the individual with chronic, asymptomatic disease.

TABLE 6

COMPLIANCE WITH REFERRAL IN %

1967 - 1973

Sex and Race	Age In Years 25-44	45-64	All
White men	56.2	73.3	64.7
Black men	42.3	45.3	43.8
White women	65.7	76.3	71.0
Black women	52.5	37.5	45.0
All	56.2	73.1	64.6

Chicago Heart Association
Heart Disease Detection in Industry

In Chicago, we have modified our program in the light of our findings and these needs. The results of our second-generation program are preliminary and time does not permit their presentation today. It should be clear that the control of hypertension, as well as control of the other risk factors, is not a simple problem. Human behavior, the root of the problem in the first place, must be dealt with in new ways if we are to reach a solution.

ROLE OF INDUSTRY IN PREVENTIVE CARDIOLOGY

Behavior Change Procedures in Controlling Diet and Smoking

W. Stewart Agras, MD

INTRODUCTION

As industry moves toward providing employees with an increasing array of opportunities for health enhancement, it becomes increasingly important to consider what is known about the behavior changes needed to achieve such a goal. Two more difficult problems than dietary change and the reduction of cigarette smoking can hardly be imagined, and most physicians can easily recall their failures in helping patients achieve these ends. Nevertheless, substantial progress has been made in these two areas in the last few years and research continues apace. This paper will briefly review this progress with especial emphasis upon information of value to the clinician in an industrial setting.

DIET

The prudent heart diet (1) recommends four goals to individuals: to attain and maintain a desirable weight; to decrease intake of saturated fats; to increase the consumption of polyunsaturated fats; and to lower the intake of cholesterol. While weight loss, dietary change, and even exercise programs should be combined in practice, for purposes of exposition weight loss and dietary change will be separated here.

Weight Loss--

The modern approach to weight control was ushered in some 15 years ago with a hypothesis that obese and non-obese persons may differ in their style of eating (2), with the obese being more sensitive to environmental events leading to eating, eating their food more quickly, and chewing it less. Research has, of course, complicated the picture. However, although the differences in eating style between overweight and normal weight individuals are fewer than was once thought, the obese do seem to eat faster and tend to choose more food than the non-obese (3). Moreover, the variation in findings between studies suggests that eating is much influenced by the social environment and may be, therefore, more easily changed by therapeutic procedures than was once thought. Finally, it seems likely that, at least in women, the obese are less active than the non-obese (4).

Given these findings, the main focus of the newer counseling methods is on the alteration of eating and exercise patterns, rather than on dieting. Such counseling often takes place in a group that meets once or twice a week for between 10 to 30 sessions. (Table 1).

Table 1. A behavioral weight control program

1.	Clarify and strengthen decision to lose weight; provide basic nutritional information
2.	Engender accurate and explicit expectancy with short term goal setting
3.	Self monitor food consumption
4.	Remove environmental cues associated with eating--e.g., remove food from sight, eat in only one place
5.	Change eating style--eat more slowly, chew food more thoroughly
6.	Reinforce behavior change
7.	Maintain weight loss--continued therapist contact, and use of self monitoring, spouse inducement in therapy

The major elements of most programs are self-monitoring, stimulus control procedures, and reinforcement of reported behavior (and weight) changes (see references 4 and 5 for detailed accounts of typical programs).

The first of these, self-monitoring, is directed toward recording the behaviors which are being changed, namely eating and exercise patterns, rather than concentrating solely on weight and calories. Indeed, in most programs calorie counting is downplayed although moderate restriction of consumption is advised. Clients are encouraged to use their records to identify their own problem areas and to concentrate their efforts upon these problems. The eating behaviors to which most counseling is directed include the elimination of cues which tend to enhance the probability of eating and of behavior which leads to over consumption. In the first category, patients are taught to remove food from sight, and to empty refrigerators and cupboards of surplus foods, especially easily consumed snacks. In addition, eating should be confined to one place, preferably sitting down at a nicely laid table. This enhances the tendency to only eat at mealtimes, and disconnects eating with such activities as reading, watching television and lying in bed. Conversely, the latter activities will become less likely to lead to eating. When serving food, smaller plates can be used so that small portions will look larger, and some food might be left on the plate at the end of the meal. This procedure should eventually lead to the selection of smaller portions, and break the habit of automatically eating everything that is served. In the second category, the overweight can be taught to eat more slowly and to chew their food more thoroughly. Thus eating utensils should be put down between bites, and second helpings, if taken at all, should be progressively delayed.

While such behavior change forms the core of most counseling procedures, attention is also given to the reinforcement of gains. This may take the form of praise and encouragement from the therapist or from other members of a therapeutic group. In addition, family members can be taught to be supportive of weight loss efforts, or at the very least not to be critical of minor setbacks. Clients can learn to reward themselves for achieving behavior change or weight loss. Money or a special occasion can be made contingent upon appropriate changes. Thus, one participant in a weight loss group used squares of brown paper to cover the view from her kitchen window, removing one square for each pound lost until she had reached her target weight.

In addition to the use of reinforcement, some therapists attempt to modify patients' self-defeating thoughts by having their clients attend to and list such thoughts, and then teaching them appropriate counter-tactics. Finally, although not much studied as to effectiveness, some form of systematic increase of exercise is usually recommended. This may take the form of building more activity into the round of daily life, for example, parking at some distance from the office or supermarket or walking up and down stairs instead of using the elevator. Or patients may elect to add a structured activity such as a walk, participation in an exercise class, or a regularly scheduled game to their daily schedule.

Self-monitoring of exercise and perhaps self-reinforcement are probably useful techniques to promote adherence to an exercise program.

What are the results of such counseling procedures? In an average program clients lose about 11 pounds (4, 5) with 90% of all participants losing weight. One problem however is the variability of obtained results. Thus at the Stanford Eating Disorders Clinic, 40 patients followed for one year lost an average of 11.3 pounds during therapy, which increased to a loss of 12.7 pounds at follow-up one year later. But the range of weight change at follow-up was from a gain of 49.5 pounds to an additional loss of 38 pounds. Such variability suggests that there is much left to learn about counseling for weight reduction, perhaps particularly in the identification of patients who do well in such programs. One propitious finding is that weight loss during the first few treatment sessions predicts outcome at the end of treatment. Thus those who will gain most from this approach can be selected early in treatment.

Some of the factors associated with enhanced outcome have been identified in well controlled clinical experiments or can be reasonably extrapolated from the literature. Thus Stuart (6) reported a mean weight loss of 37 pounds for a small group of intensively treated patients, suggesting that more frequent meetings with individualized attention may be important both in enhancing initial weight loss and in producing better maintenance. Involvement of the spouse in treatment was found in one recent controlled study (7) to lead to an average 30-pound weight loss in a group of overweight subjects at six-month follow up, a result much superior to groups not involving spouses. Finally, a recent study demonstrated that setting appropriate short term goals for weight loss led to better results than setting longer term goals (8).

These results suggest that certain specific procedures will enhance the relatively modest results obtained by behavioral weight control programs. Moreover, such programs have tended to ignore the contributions of diet and exercise to weight loss. Thus adding effective dietary counseling and an exercise program to the already described procedures of the more usual program might well lead to additional short and long term benefits.

Changing Dietary Content--
The remaining goals of the prudent diet, all of which are synergistic

with weight loss, must be achieved by dietary change, and far less is known about the most effective way to achieve such changes than is known about weight loss. Nonetheless some elements of a dietary program are clear. First, diet is a family affair. Those concerned with food buying and preparation must change their behavior, and hence need to be involved in the program. As in the case of weight loss (7) spouse involvement would be expected to significantly affect adherence to diet. Taste is not as immutable as is commonly believed. Marked divergences from common tastes or food textures are indeed likely to lead to rejection of new foods. However, a graduated introduction, for example, first mixing whole and non-fat milk, and slowly increasing the proportion of non-fat milk should lead to easier acceptance. Moreover, once a new taste is acquired, the old is likely to be rejected, thus maintaining the new and more healthful behavior. Thus family involvement and a gradual adoption of a new diet seem to be important elements in effective dietary change.

In addition, information, available in many well prepared brochures, is a necessary but apparently not sufficient component for behavior change. Added to this, demonstration of different ways to buy and prepare food is probably an important and too little used method to achieve dietary change. Obviously such demonstration should involve those concerned with the buying and preparing of food, and can be economically provided in groups.

Intriguingly, successful adoption of a prudent diet has been found possible in outpatients over rather long periods of time. Thus members of the anti-coronary club (9) were able to lower cholesterol by over 10% within the first year of that study, and maintained that lowering for five years, while a control group showed no changes. However, a substantial number of subjects dropped out of this program and were lost to follow up. Thus attention to maintenance is crucial, which in turn implies continued contact with participants. Industry, may in this respect have some unique opportunities. Thus, the cafeteria can be used as a site both to teach and reinforce a more healthful selection of food stuffs, and junk foods can be gradually eliminated from the environment, being replaced by more appropriate snacks. Moreover, continued contact with participants is made easier by their being at the industrial site.

Salt Intake--
That there is an association between excessive dietary salt intake and the development and maintenance of hypertension is suggested

by evidence from several sources (10) and one study has suggested that moderate salt restriction results in small but definite changes in blood pressure (11). As with other forms of dietary change, even moderate salt restriction involves the whole family. Information about the relationship between excessive salt intake and high blood pressure, and of the potential benefits of salt restriction for children, as a preventive measure, should be provided. Second, given that taste shows a moderately rapid adaptation to change, a sequenced program of salt restriction with each phase lasting for several weeks should prove successful. As a first step, the use of added salt at meals should cease, and the more obvious high salt snacks should not be bought. Following this, no salt should be used in cooking, and finally, food buying habits should be altered toward low salt foods. Occasional monitoring of progress by measurement of sodium excretion from an overnight urine sample might help identify families having difficulty with this regime, which difficulties can be resolved by meeting with all those involved. Given that a substantial amount of dietary salt can be eliminated from the home environment by the use of these procedures, then at least a moderate salt restriction should be achievable in most cases.

SMOKING CESSATION

The field of smoking cessation is made bewildering by the variety of approaches used, including drugs, hypnosis, various clinic programs, and aversive procedures; and by the fact that all too few of these approaches have been properly evaluated in long term controlled studies. Moreover, cigarette smoking is a strong behavior resistant to efforts to eliminate it. One reason for this is that nicotine appears to be a powerful reinforcer both in animals and man, and smoking is an efficient way to deliver nicotine to the brain. Indeed, cigarette users may well regulate their smoking to achieve a consistent nicotine level (12). Moreover since smoking is such a frequent behavior there is every opportunity for environmental events such as a cup of coffee, or a feeling of tension, to become firmly associated with smoking, and to act as cues to take a cigarette. Thus like eating, cigarette smoking is under control of the social environment.

Early systematic research into smoking cessation procedures suggested that with all therapies between 40% and 70% of participants stop smoking, but with a strong tendency to relapse, so that by six months or a year only 20%-30% remain non-smokers (13). The most useful basic approach to smoking cessation involves a combination of strongly affirming and clarifying the smoker's reasons for quitting, self-monitoring, and a gradual tapering schedule (see reference 14 for a detailed account of tapering).

As with weight management programs, self-monitoring is used to acquaint smokers with the number of cigarettes consumed, to discover the situations in which smoking is more prevalent, and to provide feedback about progress in treatment. Tapering begins by giving up cigarettes which are the least necessary, and when consumption is reduced to some 10-12 cigarettes each day, then a date for total abstinence is set. It is at this point that the maximum of attention is required. Several procedures appear to be helpful in diminishing relapse rates. First and foremost, continued contact in person and by telephone with the therapist is absolutely necessary. Second, rehearsal of how to cope with difficult situations may be useful, for example, what to say when a "friend" offers a cigarette, and even urges one to smoke. Finally the use of relaxation training may help participants cope with the aversive feelings associated with cessation (15).

Table 2. A smoking cessation program

1. Clarify and strengthen decision to stop smoking and provide relevant information
2. Engender accurate and explicit expectancy with short-term goal setting
3. Model nonsmoking behavior
4. Self monitor cigarette consumption
5. Taper to some 10-12 cigarettes each day
6. Stop smoking--specific target date; aversive procedures
7. Maintain cessation--adequate support of nonsmoking; dealing with tempting situations

Recent research suggests that two procedures may augment the results of tapering. The first of these involves the use of an aversive event made contingent upon smoking, either electric shock, or cigarette smoke itself used in a procedure known as rapid smoking. On theoretical grounds the latter procedure should be more effective since it uses an aversive stimulus in the involved sensory modality. However although some of the research findings as to the effectiveness of these procedures are contradictory, both shock and rapid smoking have been associated with success rates of 60% at one year follow-up in controlled studies (16). In the rapid smoking procedure participants inhale upon command every six seconds until they cannot proceed. After a rest period, if clients feel that they can smoke again, the procedure is repeated. This technique should not be used for smokers with chronic lung disease or known cardiac problems. Some therapists have their clients vividly recall in imagination their feelings of disgust and nausea which occur with this procedure, so that they can combat urges to smoke when they actually occur.

In the most successful use of electric shock reported to date, clients were shocked for all components of the chain of behavior, e.g., lighting a cigarette, inhaling, and so forth, and treatment continued after total cessation of smoking occurred. Only subjects exposed to shock stopped smoking, and at six months follow-up none of the subjects had relapsed.

As with weight loss programs, the use of reinforcement sometimes in explicit contracts negotiated between therapist and client, may be expected to enhance the effectiveness of whatever treatment is being used (16).

The second approach to smoking cessation of some promise involves the interaction between an ongoing community cardiac risk factor reduction campaign and a tapering procedure used in a group contest. Two years after treatment 44% of those participating in the group remained non-smokers, compared with 12% in comparable participants exposed only to the community campaign (17). These results may be particularly important to industry, since the use of an ongoing health campaign to strengthen the effects of smoking cessation efforts is of course possible. Moreover, maintenance can be assisted in the industrial site, by providing areas for non-smokers in cafeterias, and by limiting the areas in which smoking is permitted.

CONCLUSION

Industry provides an excellent site for the use of behavior change procedures to enhance health. Employee participation is likely to be high and drop out rates low, thus enhancing the probability of maintaining achieved results. As we have seen, much can be done to enhance healthful behavior within the work environment by improving cafeteria offerings, restricting the sale of "junk" food, and confining cigarette smoking to certain areas. Moreover, a positive campaign to enhance health by providing information via posters, printed material, and lectures can be devised and implemented. Such a campaign, which should be continuous, is likely to increase participation in behavior change programs and also to enhance maintenance of change.

Finally, research in the applied behavioral sciences continues to expand the range of procedures useful to achieve the life style changes needed to enhance health. As we have seen in the areas of dietary change and smoking cessation, the procedures are becoming increasingly well specified, and many manuals are available both for the group leader and participants. Just as such programs need skilled medical advice, so do they also need input from behavioral scientists acquainted with these areas of research. Only then will the maximal results be achieved.

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ROLE OF INDUSTRY IN PREVENTIVE CARDIOLOGY

Exercise Prescription in an Industrial Fitness Program

Robert E. Dedmon, MD

INTRODUCTION

In an effort to curtail skyrocketing costs of health care, several companies have begun to develop prevention or health promotion programs. These vary from recreational programs and subsidized YMCA memberships to highly structured cardiovascular fitness programs with or without in-house medical screening facilities and associated health education programs (1-4). Objectives of such programs include reduced costs for medical care, decreased absenteeism, and increased employee enthusiasm and productivity. Clear demonstration of these benefits remains to be achieved.

The value of vigorous physical activity in either the prevention of coronary heart disease or the prolongation or survival in coronary heart disease patients is under considerable debate (5-24). While appropriate supervised exercise is probably a valuable part of any coronary heart disease (CHD) preventive program, it is unlikely to prove beneficial unless combined with a broader program of risk factor intervention and life style change. Unsupervised vigorous aerobic exercise in sedentary individuals over 40 years of age is hazardous and should not be encouraged. A good example of a large scale national prevention effort is the Operation Life-Style program of the Canadian Ministry of Health (25,26). The Operation Lifestyle Profile (27) portion of this program has been used successfully by Kimberly-Clark Corporation as a motivational tool in our new corporate Health Management Program.

The NASA study (28) showed that employees participate in such programs for many reasons including organization and leadership, exercising in general, recreational aspects, camaraderie, and health benefits. While these data are subjective, they do give us a basis for designing employee fitness programs. A subsequent report from NASA (29) has also suggested benefit from such a program, although no conclusive affect on CHD morbidity or mortality was demonstrated. Table 1 shows several features shared in common by successful fitness programs.

KIMBERLY-CLARK HEALTH MANAGEMENT PROGRAM

Kimberly-Clark Corporation, like other companies, has invested much time, money, and other resources in the development of a comprehensive preventive or prospective medicine program entitled the Health Management Program. The program is available to the 2,000 corporate salaried employees of all levels residing in the Fox Valley area of Wisconsin (Appleton and Neenah-Menasha).

The Health Services Center includes a multiphasic screening area, an exercise facility, and an educational conference area. Screening procedures include urine and blood analysis (CBC, SMA-12 including triglycerides, HDL cholesterol, and lipoprotein phenotyping), vision and hearing testing, tonometry, chest x-ray, pulmonary function, percent body fat by skin fold thickness and body density by underwater weighing, physical examination, and treadmill testing with a computerized system by Marquette Electronics of Milwaukee with simultaneous direct measurement of VO_2 Max. by a Metabolic Measurement Cart by Beckman Instruments, Inc. of Schiller Park, Ill.

The exercise facility includes a 25-meter Olympic pool; a 100-meter suspended track; exercise equipment; a gym area for calisthenics and other aerobic exercise; 1,000 lockers (500 each, male and female); showers; two saunas; a whirlpool; and a lounge and dining area with vending machines. Our exercise facility is open from 5:00 A.M. to 9:00 P.M. Monday through Friday and 8:00 A.M. to 5:00 P.M. on Saturdays.

The Health Services Center staff includes 15 people:

- 1 Physician (Staff Vice President - Medical Affairs);
- 1 Manager of Health Services with a masters degree in exercise physiology;
- 1 Masters degree nurse-practitioner;
- 1 Coordinator of Special Health Services with a masters degree in psychology (Employee Assistance Program);
- 2 RN's;
- 3 Technicians for multiphasic screening and treadmill testing;

1 Masters degree level physical education specialist;
1 Executive secretary;
3 Receptionists, and
1 Clerk-typist

Table 2 shows an overview of our program and staff.

Programs include health screening, aerobic exercise, cardiac rehabilitation, health education, employee assistance for alcoholism and drug abuse, and individual and group risk factor intervention counseling.

A detailed discussion of treadmill testing is beyond the scope of this presentation, but key references are included in the bibliography (30-37). We employ the Bruce Protocol whenever possible. All center personnel are fully trained in cardiopulmonary resuscitation. Qualified personnel are also trained in appropriate advanced life support procedures, including defibrillation by DC counter-shock. Informed consent is strictly observed. Community internists assist the corporate medical director with physical examinations and treadmill testing. Because we expect a large number of false positive exercise tests, particularly in women (38), we are trying to determine suitable criteria for referral for thallium scanning and/or angiography in asymptomatic persons. At the present time, those suggested by Cohn (39) seem most reasonable and include:

1. ST segment depression early in the exercise test;
2. 2.0 mm of ST segment depression persisting at least one minute post-exercise (with the ST segment flat or inverted for at least 80 m sec past the J point); and
3. The presence of other risk factors.

Time does not permit discussion of all our risk factor intervention programs. Therefore, I will limit discussion to our exercise program and our approach to exercise prescription for the employee population.

General principles of exercise prescription--
These are shown in Table 3. Exercise prescription may be individualized or by group according to age, treadmill estimated functional capacity and VO_2 Max, the presence of risk factors or known CHD, and the presence of orthopedic abnormalities. Table 4

Table 1. Common features of successful programs

1. Strong leadership
2. Administrative support; with personal and financial commitment
3. Accessibility (On-site or nearby facilities)
4. Availability (The right programs offered at the right times)
5. Assessment (Continuing evaluation of fitness, anthropometry and performance)
6. Recording (Techniques should be devised for monitoring the progress of participants)
7. Group exercise. (Large-scale fitness improvement is unlikely to be accomplished exclusively by individual programs)
8. Challenging physical programs. (Participants come to be improved, not humored)
9. Continued motivation, stimulation and incentive
10. Organization (Careful attention to the mechanics and details of program operation)
11. Visibility and variety
12. Continuity and extension (The program should work with, and not against, related company and community organizations)
13. Fun

Table 2. Kimberly-Clarks' health management program

An Overview	
Lifestyle evaluation	Breast self-examination
Medical history and health hazard appraisal	Risk factor reduction
Multiphasic screening	Employee assistance (alcohol and drug abuse)
Physical examination	Exercise
Treadmill testing	Cardiac rehabilitation
Eating behavior modification	
Full Time Staff (14)	
Staff vice president - medical affairs	Health management specialists (male and female)
Exercise physiologist	EAP coordinator
Nurse practitioner	Receptionists
RN's	Secretaries
Technicians	
Part Time Staff	
Community physicians (internal medicine/ cardiology)	RN
Other	
Physician Advisory Committee - Local community	

Table 3. Principles of exercise prescription

1.	Determine functional capacity by graded exercise testing
	A. Treadmill or bicyble ergometer
	B. Rule out presence of coronary heart disease
2.	Cardiology or personal physician consultation
3.	Determine the exercise to achieve desired training effect. Type, frequency, duration, intensity
4.	Orthopedic considerations
5.	Individual targets Heart rate, blood pressure, EKG changes, weight, endurance
6.	Education and motivation for adherence
7.	Program features Fun, well organized, camaraderie, attainable goals

Table 4. Target levels for training

I - "Normals"

- A. O_2 uptake - 57% to 78% VO_2 max
- B. Heart rate - 70% to 85% max heart rate attained
  70% to 85% age predicted maximal heart rate
- C. Systolic BP - Maximal level of 225 mm Hg
  Watch for fall in systolic BP

II - Sympomatic Patients

- A. O_2 uptake - 57% to 78% VO_2 max
- B. Heart rate - 70% to 85% max heart rate attained
- C. Other - EKG - PVC's
  IV and A-V block
  ST depression (3-4mm)
  BP - abnormal response (fall > 20 mm Hg)
  Signs and symptoms

shows normal target levels for training. It is very important to prevent "Type A" (40) employees from attempting to correct ten or more years of inactivity by two days of hyper-exertion (41)! Acute coronary fatalities are not conducive to a successful company exercise program. Exercise sessions conducted for employees with angina pectoris, previous myocardial infarction or previous coronary by-pass surgery, and others at high risk are conducted with a physician and R N in attendance and defibrillation equipment operational. A limited number of telemetry units are also available, and Holter monitoring is employed in selected persons for 12-24 hours post-exercise.

In most company fitness programs, exercise prescription will be used for apparently normal individuals with sedentary occupations, many of whom are overweight and in poor physical condition. Many will also have abused food, alcohol, and tobacco to varying degrees. The most important aspect of the program will be to achieve an alteration in lifestyle - a supervised exercise program being part of that process.

Prescribed exercise must be both conservative and aggressive (42). It must not push a person beyond 85% of his maximal performance capability as estimated by graded exercise testing; yet, it must be adequate to produce a cardiopulmonary conditioning effect. There are four factors to consider in any exercise prescription and these are shown in Table 5, and include type, frequency, duration, and intensity of exercise.

Acceptable types of exercise for cardiorespiratory fitness are shown in Table 6 and include walking, jogging, swimming, outdoor and indoor cycling, rope jumping, and long distance running. Weight lifting and isometric exercises are not acceptable for this purpose. Contact sports in sedentary individuals are not recommended because of the high incidence of injuries. Common everyday activities such as walking, climbing stairs, and gardening should also be encouraged. Golf is relaxing, but inadequate for aerobic conditioning. Tennis requires seven hours of singles per week to produce an adequate training effect. While facilities for racketball, squash, and handball are not always available, these sports can produce an adequate training effect if participation is regular.

The frequency of exercise (Table 7) must be at least three times weekly. While daily exercise is desirable, properly regulated

Table 5. Exercise prescription

1. Type (aerobic)
2. Frequency (3 times a week)
3. Duration (20 minutes at training heart rate)
4. Intensity (70%-85% capacity)

Table 6. Types of exercise

Selection of the type of exercise takes into consideration:

1. Individuals personal preference
2. Individuals time schedule and lifestyle
3. Limiting physical factors

Types of exercise recommended include:

Walking	Swimming
Jogging	Rope jumping
Cycling	Cross country skiing
Aerobic dance	

Table 7. Frequency

First 4 months

Individuals initiating an exercise program should limit exercises to 3 times per week on alternate days (Example: Monday, Wednesday, Friday)

After first 4 months

Individuals continuing an exercise program beyond 4 months can increase frequency to 5 or 6 days per week.

sessions of three times a week are suitable in achieving reasonable levels of fitness.

The duration of exercise required to achieve cardiorespiratory fitness objectives varies, but should be for a minimum of 20 minutes. An optimal session should include five or more minutes of warm up exercises to stretch and condition muscles, 15-20 minutes of aerobic exercise at the training heart rate, and five minutes for cooling down by walking or other submaximal activities. Shorter periods are often prescribed initially to develop muscle strength.

Intensity of the exercise performed is probably one of the most important items to be considered. Close attention to supervision of this factor is very important, particularly when highly competitive, "Type A", executives are involved. During the beginning phases of an exercise program, intensities of more than 75% of a person's work capacity should be avoided. The appropriate level of intensity can be determined by heart rate response, VO_2 max, or physical work performed. In our own program, we use VO_2 max, either measured directly or as estimated by treadmill time (30,43).

Table 8 shows a sample exercise prescription form. Exercise should be reduced or curtailed in the presence of active infection or injury to the extremities. Aching joints and muscles and early fatigue may be the result of excessive exertion and should be evaluated appropriately. High altitude and extremes of temperature also require modification of activity. Another note of caution is that hot showers immediately after exercise may cause syncope or frank symptoms of myocardial infarction.

Cardiorespiratory fitness level programs--
Company exercise programs designed to achieve cardiorespiratory fitness require supervision. The ideal combination is an exercise physiologist and a physician (44) but this is not always practical. In the event that supervision of exercise is not available, a program of longer duration at low intensity is advisable with slow progression to submaximal heart rates. Treadmill or bicycle ergometer exercise testing is important prior to vigorous aerobic exercise in sedentary individuals over 35 years of age.

The Committee on Exercise of the American Heart Association has published two books (30,31) of guidelines for exercise testing

Table 8. Exercise prescription form

NAME ______________________ Extension ______________

Personal Physician ______________________

Age __________ Sex __________

FITNESS CATEGORY I II III SPECIAL

Type of Exercise ______________________

Frequency ______________________

Duration ______________________

Intensity - HR ______________________

- METS ______________________

Retest ______________ Weeks/Months

Date ______________ Provider (N.P. or M.D.) ______________

Table 9. Classification of fitness level by oxygen consumption

	Male	Female
CLASS I (Least Fit)	VO_2 Max 31-39 ml/kg/min	VO_2 Max 25-29 ml/kg/min
CLASS II	VO_2 Max 40-44 ml/kg/min	VO_2 Max 30-34 ml/kg/min
CLASS III (Most Fit)	VO_2 Max 45 or more ml/kg/min	VO_2 Max 35 or more ml/kg/min

and fitness training of healthy individuals and those at high risk for or with a clinical history of coronary heart disease. Anyone embarking on a program should be familiar with these. Cooper's <u>New Aerobics</u> (45) also contains many helpful suggestions. In addition, the Chicago Heart Association (46), Dr. Lenore Zohman (47) and Professor Astrand (48) have published concise and informative exercise guidelines for laymen. Table 9 shows the levels of fitness used for exercise prescription in our program.

Table 10 shows estimated VO_2 max values for the treadmill protocol calculated from multivariate regression equations as suggested by Bruce (30,43). Table 11 shows the calculated values for VO_2 max in one adult male tested in our program.

Table 12 shows a sample exercise prescription for a healthy adult and Tables 13-15 provide similar data for a patient with angina pectoris. Those persons who have had myocardial infarction or coronary by-pass surgery should participate in progressive exercise under proper medical supervision and preferably as part of a cardiac rehabilitation group. While post-coronary marathon runners have been reported (49-51), the majority of CHD patients should not be expected to progress to this level of activity. Essential features of a post-coronary exercise group are presented in Table 16.

CONCLUSION

Finally, I wish to mention some key and unanswered questions:

1. Does physical exercise prolong survival in coronary heart disease?
2. Does it have any effect on the atherogenic process?
3. Does it afford any protective effect against anoxia?

That physical exercise does significantly improve a subjective sense of well-being and physical work capacity has been clearly demonstrated (14,52). In addition, we hope that company preventive medicine programs will be effective in enhancing employee health, reduce absenteeism and health costs (53), and improve work performance. We all look forward to the proof of this proposition.

Table 10. Calculated VO_2 max from Bruce protocol treadmill time

Treadmill min	VO_2 max Male	Female
3	16.5	12.6
4	19.4	15.5
5	22.4	18.4
6	25.3	21.4
7	28.2	24.3
8	31.2	27.3
9	34.1	30.2
10	37.1	33.1
11	40.0	36.1
12	42.9	39.0
13	45.9	42.0
14	48.8	44.9

Table 11. Treadmill time, calculated VO_2 max, and fitness level in an adult male subject without evidence of coronary heart disease

Example: 37 year old male "normal"

Treadmill ime (Bruce) - 8 minutes
Maximal heart rate - 186/min
Calculated VO_2 Max - 31 ml/kg/min
Fitness category I (least fit)

Table 12. Exercise prescription for "normal" adult male subject in fitness category I

Type: Walk/Jog
Frequency: 3 times/week
Duration: 30 minutes
Intensity: 2 miles in 30 minutes (5 METS) progress to 2 miles in 24 minutes in 12 weeks (7 METS)

Table 13. Exercise prescription for a 52 year old female with angina pectoris

Treadmill time (Bruce) - 4 minutes (chest pain)
Calculated VO_2 max - 15.5 ml/kg/min (4 METS)
Maximal heart rate - 140
Train at 60% - 9.3 ml/kg/min (2.6 METS)
Training heart rate - 100-120 (70%-85% MHR)
Walking 2 miles/hr
Cycling-5 miles/hr

Table 14. Cardiac exercise format for a 52 year old female with angina pectoris

Period	METS	ml O_2/kg/min	Exercise
Warm-up	1.5	5.3	0.3 mile/10 min
Training	2.5	8.8	1.0 mile/30 min
Cool down	1.5	5.3	0.3 mile/10 min

Table 15. Subsequent prescriptions for a 52 year old female with angina pectoris

1. Same warm up and cool down
2. Walk 1.5 miles in 24 minutes for 3 weeks
   4 METS - 14 ml O_2/kg/min
3. Walk 2.5 miles in 40 minutes for 3 weeks
   4 METS - 14 ml O_2/kg/min
4. Progress to 4 miles in 60 minutes at 15th week
   5 METS - 18 ml O_2/kg/min

Table 16. Group program for post-myocardial infarction exercise

1.	Three months post infarction.
2.	Controlled or treated Hypertension Arrhythmias Congestive Heart Failure
3.	Three sessions per week
4.	Physician present
5.	EKG, defibrillator, emergency drugs, oxygen
6.	Exercise period a. warm-up and cool-down b. calisthenics c. walk - jog d. group activity e. physician participation

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ROLE OF INDUSTRY IN PREVENTIVE CARDIOLOGY

Cost Effectiveness in Hypertension Management

William B. Stason, MD, MS

INTRODUCTION

I am here today to ask you to rewrite the Hippocratic Oath. As the slide says: I swear by Apollo, the physician on Aesculapius, and Health and All-heal, and all the Gods and Goddesses that according to my ability and judgment - and cost considerations - I will keep this oath and stipulation. Consideration of costs in the delivery of medical care is controversial, and, for some, even untenable. After a recent presentation on cost-effectiveness analysis, an irate physician rose from the audience to claim that it was his duty to provide everything possible for every patient, regardless of costs, and that consideration of costs was incompatible with high-quality medical care. Perhaps some of you support this point of view.

This afternoon I would like to argue for cost consciousness by physicians; to indicate how cost-effectiveness principles can be applied to one important problem in preventive cardiology, namely, hypertension; and, finally, to suggest some means by which the cost of care for hypertension can be reduced without loss of quality.

Imperative for Cost-Consciousness--
If medical care were free and medical resources were unlimited, there would be no need to deviate from the dictum of "everything for every patient." Unfortunately, such is not the case. Medical care is not free. What the patient doesn't pay himself, his employer or the taxpayer does. Furthermore, medical resources are not unlimited. No one sees this more vividly than you do as your busy office schedules erode away your evenings and weekends or when scarcity of hospital beds delays a necessary hospital admission. Under conditions of limited resources, costs are important and priorities do have to be set. Everything possible cannot be done for every patient. My guess is, in fact, that you, in your practices,

set such priorities daily as you allocate more or less of your time to one patient or another based upon your assessment of the needs of the patient and your ability to benefit him. The question, really, is not whether cost-effective clinical decision-making is necessary and ethical, but rather one of who makes the decision and where and how the line is drawn. My argument, fundamentally, is that priorities should be set such that the maximal health care benefits can be realized per dollar spent, per hour of your time expended, or per hospital bed-day utilized.

The pressure for cost-containment in medicine is real and growing stronger day by day. We hear it from the government, from employers, and from patients alike. The only question is how it will be implemented; whether from Washington by establishment of caps on hospital revenues, limitations on hospital beds and diagnostic facilities, constraints on reimbursement under national health insurance, and tighter control on technology, or from within the medical profession through efforts by physicians to improve efficiencies of their office practices and hospitals and by efforts to ensure allocation of medical resources to patients most likely to benefit from them. I, personally, would much rather see decisions about health care made by those most qualified to make them, namely, by health professionals. Greater cost-consciousness by physicians and explicit consideration of costs in the making of clinical decisions are critical elements in this process. Systematic consideration of costs in cost-effectiveness or cost-benefit analyses, as I will discuss today, can also help by increasing awareness of the problem and by providing some insights into how cost containment might be achieved.

HYPERTENSION

Hypertension provides an interesting case in point. What are its medical and economic consequences? There is no doubt that it is an important health problem. Upwards of 24 million Americans have blood pressures above 160/95 mm Hg. The consequences of elevated blood pressure, as you all know, are enormous in terms of increased risk of cardiovascular disease, premature death and disability. Industry has a special interest because of the lost productivity that results and the necessity to replace key employees who are lost prior to normal retirement ages. For industry, the expense of training skilled personnel may well warrant considerable efforts to ensure that hypertension is detected early and treated effectively. Efforts to reduce stress in the work environment, encourage exercise and cultivate healthy dietary habits may well be more cost effective than many other measures that result from executive decision.

How good a use of medical resources is the treatment of hypertension? What would be the health consequences if all hypertensives were provided life-long, effective treatment? At what cost? Definitive answers to these questions are not available. What is possible, however, is to present a framework from which tentative answers can be obtained and from which more conclusive answers may be developed in the future as better data become available.

Costs--

First, what are the costs of treating hypertension? Direct medical care costs, including the costs of medications, physician time and laboratory examinations are by all odds the most important. For essential hypertension these can range from $100 to well over $400 per patient per year with the costs of medications, in most instances, being by far the major item. These figures exclude costs of detection and initial diagnostic evaluation. The latter, as you well know, may be considerable. Because treatment is generally life-long, life-time costs for an individual may amount to many thousands of dollars. Treatment of hypertension is by no means a free ride

Table 1. Net cost

Direct medical care costs
Indirect costs
Savings in morbidity prevented
Costs of treating side effects
Costs of health care in added years of life

On a national level, if all persons with sustained blood pressures of 165/95 mm Hg or above were treated, direct medical costs would be in excess of $5 billion per year. To this would be added the costs of monitoring perhaps 15 million individuals with transient or borderline hypertension.

To these direct costs must be added the indirect costs of treating medication side-effects, such as depression or acute gout, and the costs of treating diseases that would not have occurred if the patient had not lived longer as a result of treatment of hypertension.

On the other side of the ledger, credit must be given for savings in the medical costs required to treat the cardiovascular morbid events that will be prevented by treatment, especially strokes and myocardial infarctions. These, in a sense, are the costs of not treating hypertension. Ignoring the problems of maintaining long-term treatment, we estimate that only about 30 percent of treatment costs would be recovered. When problems with adherence are taken into account, this figure, undoubtedly, would be much smaller. The excess medical care costs incurred, therefore, must be justified in terms of the increased longevity, reduced disability, and improved productivity or quality of life that result.

Benefits--

Benefits of treatment can be measured in many ways. Years of increased life expectancy are, probably, the most important, but the quality of those years also needs to be considered. Pain and suffering, limitations on active work or leisure time activities, and the side-effects and inconveniences of treatment all detract from the quality of one's life (Table 2).

Table 2. Net effectiveness

Increased life Expectancy
Improved quality of life from morbidity prevented
side effects of treatment

There are many problems in measuring the benefits of anti hypertensive treatment. The most important is that we don't really know how effective treatment is. To what extent does successful contol of blood pressure reduce the risk of early death, myocardial infarction or stroke in a hypertensive? Does it reduce this risk to that of a person who has been normotensive all his life, or does it only partially reduce this enhanced risk? Furthermore, to what extent does this reduction of risk depend upon the duration of treatment, the age at which treatment is begun, and on the degree of blood pressure control achieved? The answers to these questions are not known with any certainty. Treatment of mild hypertension provides a special problem because of the enormous number of patients involved - 70% to 80% of hypertensives have DBP less than 105 mm Hg - and the lack of definitive evidence that treatment is effective. Even if it is effective, its benefits may be outweighed by the risk of medication side effects and the costs and inconvenience of treatment.

The other major problem is that of measuring quality of life. In some analyses, the quality of life is equated to absenteeism from work and is, therefore, measured in terms of lost wages or productivity. Hypertensives appear to experience nearly twice the absentee rates of the general public. Whether this higher rate can be attributed directly to disability resulting from hypertension, however, is not clear. A recent study suggests that the mere fact of being labelled as a hypertensive and being treated for it increases absenteeism, in the absence of any evidence of physical disability. Absenteeism data need to be interpreted with these possibilities in mind.

Another way to measure quality of life, and the way we have chosen, is to get individuals to subjectively estimate the tradeoff between years of life and disability by evaluating responses to the question: "Taking into account your pain and suffering, immobility, age and lost earnings, what fraction of a year of life would you be willing to give up in order to have good health for the remaining fraction of the year instead of your present level of disability for the full year?" An answer near one implies that the disability is nearly as bad as death; and answer near zero, on the other hand, implies a mild or negligible level of disability. This tradeoff, admittedly difficult, is not impossible. Wouldn't you agree, for example, that a year of life with severe angina pectoris, is worth less than a year of life with full health? Wouldn't you be willing to trade a bit of your remaining years of life to be free of such symptoms? My guess is that you would. The question is, how much? Similarly, the adverse side-effects of treatment must surely be considered in evaluating the net effectiveness.

Cost-Effectiveness of Treatment--
Having discussed some of the issues involved in measuring the costs and the benefits of treatment for hypertension, how then can we combine these to give an answer (or answers) to the question of: "How good an investment is treatment of hypertension?" In one approach, so called benefit-cost analysis, all benefits, as well as costs, are expressed in economic or dollar terms. Thus, the cost of a premature death or disability usually is valued in terms of lost earnings. The ratio of benefits to costs is calculated, and if this is greater than one, the argument is made that the program should be undertaken; if it is less than one, the program should not be undertaken. The problem with this kind of analysis is in the need to assign a dollar value to a year of life or a day of disability. Difficult questions arise. For example, should all years of life be valued equally, or should the value of a year of life vary with the earnings of an individual? This dilemma is especially keen for housewives and for retired or unemployed individuals. An alternative approach, that we find more attractive, is to express results in terms of the dollar cost per year of life saved or per year of life adjusted for its quality. The tradeoff between dollars and lives is, therefore, avoided and anyone interpreting the results is free to make his own judgment as to what the value of a year of life should be. This is cost-effectiveness analysis. The lower the cost-effectiveness ratio, the higher the priority the practice in question should have.

In a benefit-cost analysis performed by the National High Blood Pressure Education Program, it was found that, for hypertensives aged 35 to 64 with diastolic blood pressures of 95 mm Hg and above, the overall benefit-cost ratio was 1.24. The benefits of treatment were found to just about equal the direct medical care costs, but costs savings from the treatment of cardiovascular events increased the ratio by the additional 24 percent. Informally, I've been told that this ratio has been revised upward in a subsequent analysis. By the standards of cost-benefit analysis, then, treatment of hypertension does look like a reasonable investment.

How does this compare with the results of our cost-effectiveness analysis? Despite striking differences in the methodologic approach, the results, overall, are remarkably similar. Figure 1 presents the estimated cost-effectiveness of treatment by sex, age, and pretreatment level of diastolic blood pressure. Full adherence of patients to treatment is assumed at this stage, but the problem of non-adherence will be considered shortly. Remember that the lower the value of a cost-effectiveness ratio, the higher the priority in terms of maximizing benefits from a given health expenditure. Results are discounted to account for the fact that both costs and benefits accrue over the lifetime of the patient.

For both sexes, cost-effectiveness is inversely related to the pretreatment level of blood pressure. This is certainly not unexpected. For a 40-year-old woman, for example, treatment of a diastolic blood pressure of 100 mm Hg results in a net cost of about $10,000 per year of quality-adjusted life expectancy saved while for 110 mm Hg, the estimate is $6,000.

Important differences between men and women are also evident. For men, at each pretreatment level of diastolic blood pressure, cost-effectiveness decreases with age, implying that resources are more efficiently used in younger men. The converse is true for women, due to the later occurrence of strokes and myocardial infarctions in women than in men. The crossing point for the sexes is between ages 40 and 50. The estimated cost-effectiveness of treating young men is particularly striking, although the data upon which this conclusion is based are less secure than for other age groups. Figure 2 shows how the cost-effectiveness of treatment depends not only on the initial blood-pressure level, but also on the level achieved by treatment. The results are for 40 year olds. For a man whose initial diastolic pressure is 100 mm Hg, the estimated cost-effectiveness value is about $11,000 if his pressure is reduced to 100 mm Hg; and $5,000 if 90 mm Hg is attained.

Results such as these can be used for setting priorities, for initiating treatment and in allocating your time between efforts to achieve blood pressure control in different patients. (Presupposing, of course, that you can be seduced into accepting cost-effectiveness criteria.) Where you will draw the line will depend upon what value you want to assign to a year of life. Figure 2 shows combinations of age and pretreatment DBP according to specific values of the cost-effectiveness ratio. If a criterion of $10,000 per year of life were chosen, one would initiate treatment in a 30-year-old man if his DBP was above 96 mm Hg and in a 30-year-old woman if it were above 101 mm Hg. Corresponding levels could be selected for a criterion of $15,000 and $6,000.

Thus far, we have assumed full adherence to anti-hypertensive regimens. The well documented failures of patients to adhere to medical regimens, especially long-term ones, can severely compromise the cost-effectiveness as well as the effectiveness of treatment. A patient who continues to use medical resources by visiting his physician and by purchasing medications, but who does not take those medications, imposes a cost without receiving corresponding benefits. The impact on cost-effectiveness depends on whether medications are purchased and not consumed, the worst case, which we call our maximum cost assumption, or whether the patient simply continues to visit the physician but purchases medications only in proportion to their consumption, our minimum cost assumption. Obviously, if a person drops out of treatment he neither receives benefits nor incurs costs. Estimates of the cost-effectiveness of treatment under the assumption of an effective adherence rate of 50 percent, as has been recorded in the literature, are shown in Figure 3. These estimates compare the results of treating mild hypertension with those of treating moderate or severe hypertension for 40 year olds. If treatment were provided for patients with diastolic pressures of 105 mm Hg or above, the average cost per year of increased life expectancy would range from $10,500 under incomplete adherence, if medications are purchased but not taken, to $4,850 under full adherence. Corresponding figures for treating mild hypertension range from $20,400 to $9,900. It is clear that problems with adherence seriously compromise the cost-effectiveness, as well as the effectiveness, of treating hypertension.

These findings have obvious implications for treatment programs. They also should be taken into account, however, when evaluating hypertension screening programs. The failure of newly identified hypertensives to be successfully referred and to receive treatment and, then, to remain under effective long-term care severely detracts from the potential benefits of such programs. Certainly, screening programs should be undertaken only if adequate arrangements and facilities exist such that detected hypertension can be translated into controlled hypertension. Investment in efforts to improve patient adherence may be a much more effective use of resources than widespread public screening.

CONCLUSION

In conclusion, I would like to emphasize four points. First, from data currently available, I cannot say, in any absolute sense, whether treatment of hypertension is a good investment or not. Is $10,000 or $20,000 per year of life saved a good investment? To answer this question, comparisons with alternative uses of health care resources are obviously needed. For example, the cost-effectiveness of treatment for hypertension needs to be compared with that for angina pectoris. Second, standing alone, the results of our analysis can provide certain guidelines for setting priorities within our individual practices. Treatment of higher pressures and younger men should receive the highest priorities. Furthermore, special attention should be given to actually achieving defined goal blood pressures and to improving long-term patient follow-up. Third, analyses such as this suggest ways in which we might contain the costs of our practices while sacrificing little in the way of quality. Judicious choice of laboratory examinations; emphasis on use of generic drugs; and simplification of drug regimens to the maximal extent consistent with achieving blood pressure control are some means to this end. Increased use of nurse practitioners to assume much of the responsibility for the long-term management of hypertensives is another means. The paraprofessional follow-up model is particularly well adapted to industrial clinics as demonstrated so well by Doctor Alderman.

Finally, it is important to stress that our results pertain only to current knowledge and current health practices. As we learn more about the causes of hypertension, preventive measures such as changes in dietary habits or life styles may become possible and may reduce the magnitude of the hypertension problem. Likewise, pharmacological research may lead to more effective and less expensive medications; and the development of alternative therapies, such as biofeedback, may reduce the need for drug treatment. As the characteristics of these developments become known, they can be incorporated into the analysis and their impacts determined.

In the meantime, I hope you will be challenged by this cost-effectiveness approach to evaluating medical care -- challenged to improving upon it and making it more practical to your needs or challenged to discover a better alternative. Above all, I hope you will be challenged to increase your awareness of costs as they apply to your practices.

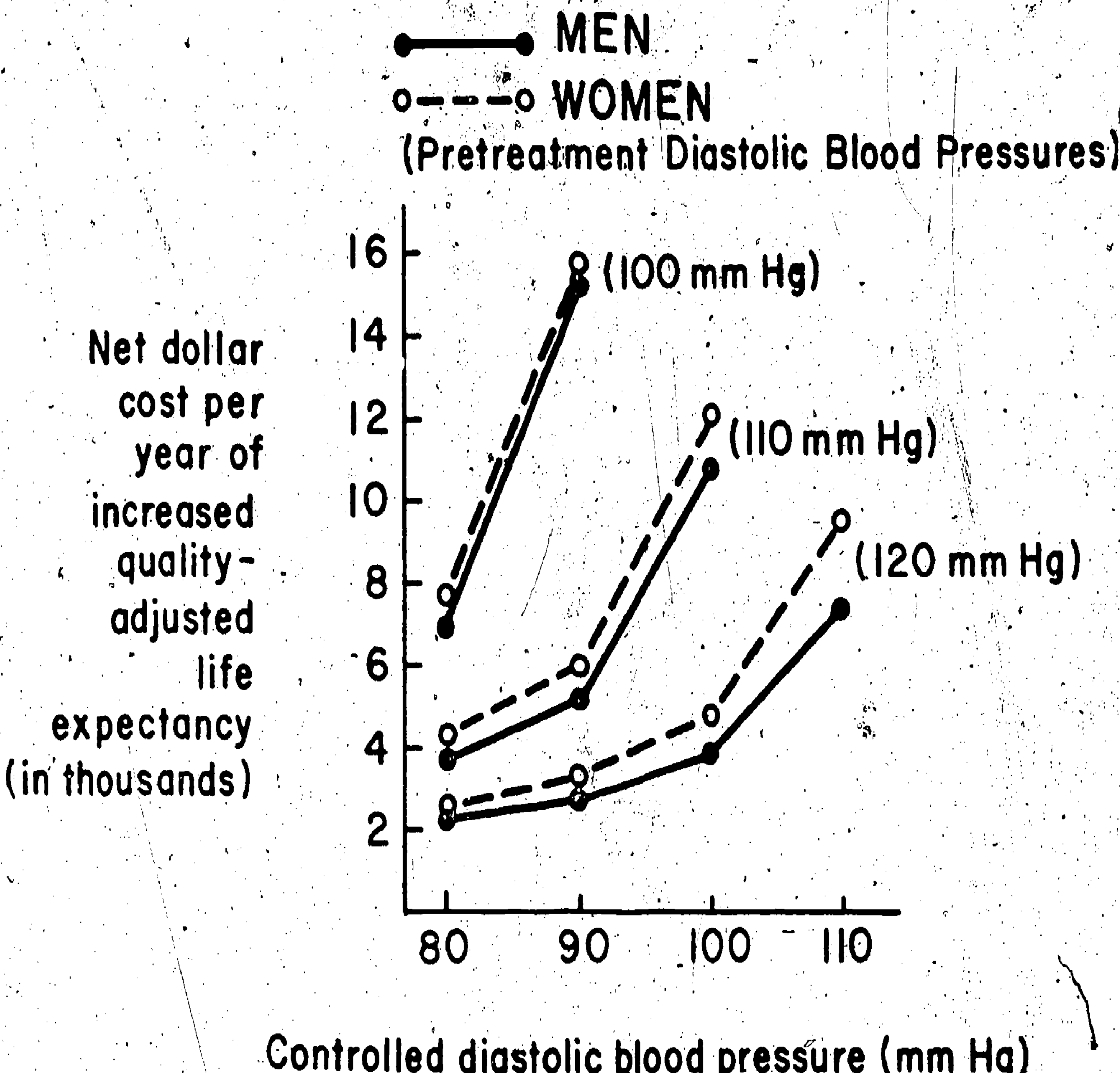

Figure 1. Estimated cost-effectiveness of treating hypertension by sex, age, and pretreatment diastolic blood pressure, and assuming full adherence to therapy.

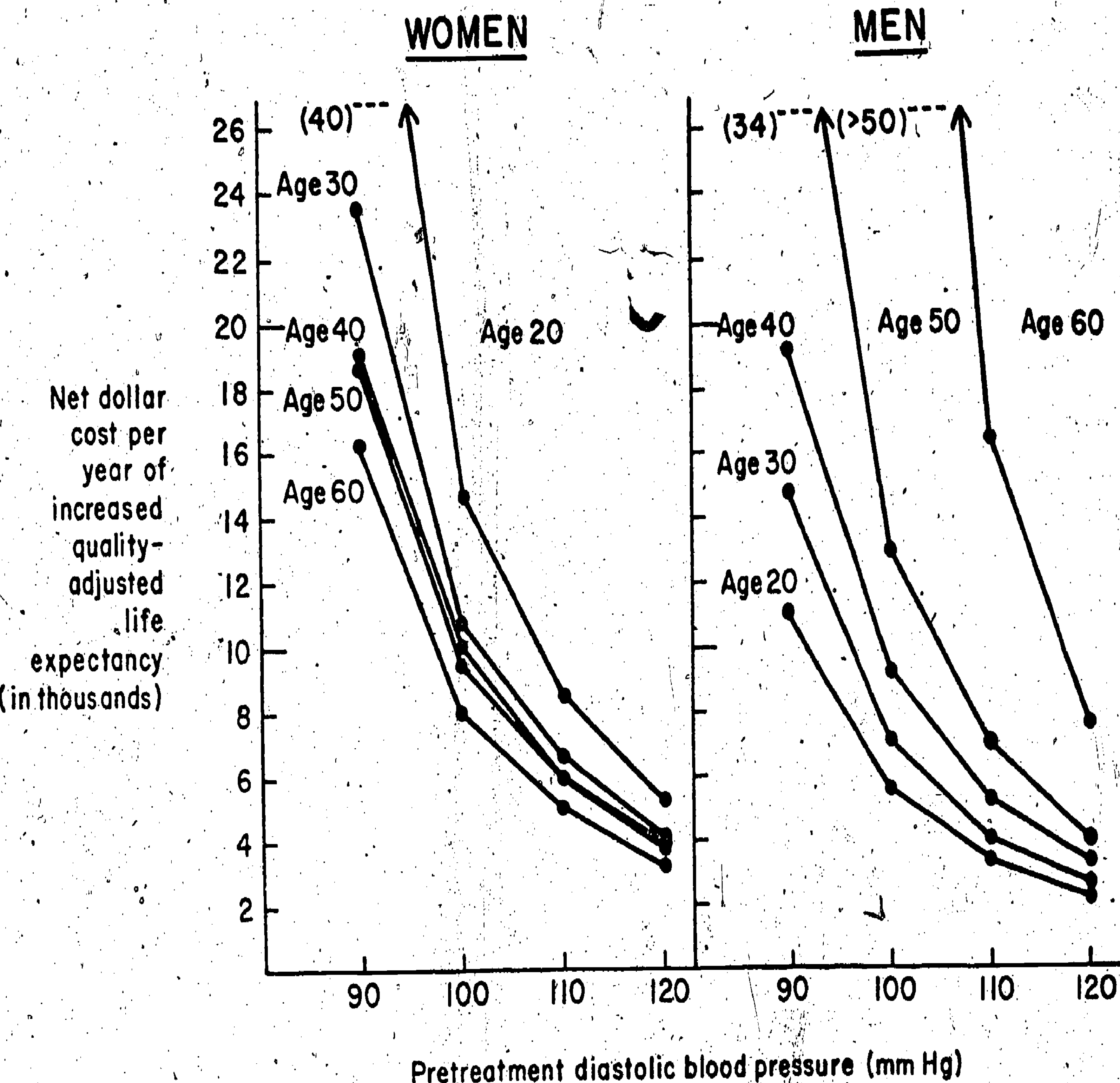

Figure 2. Cost-effectiveness of treatment for hypertension by pretreatment and post-treatment diastolic blood pressure. Results are for 40 year old males and females, assuming full adherence.

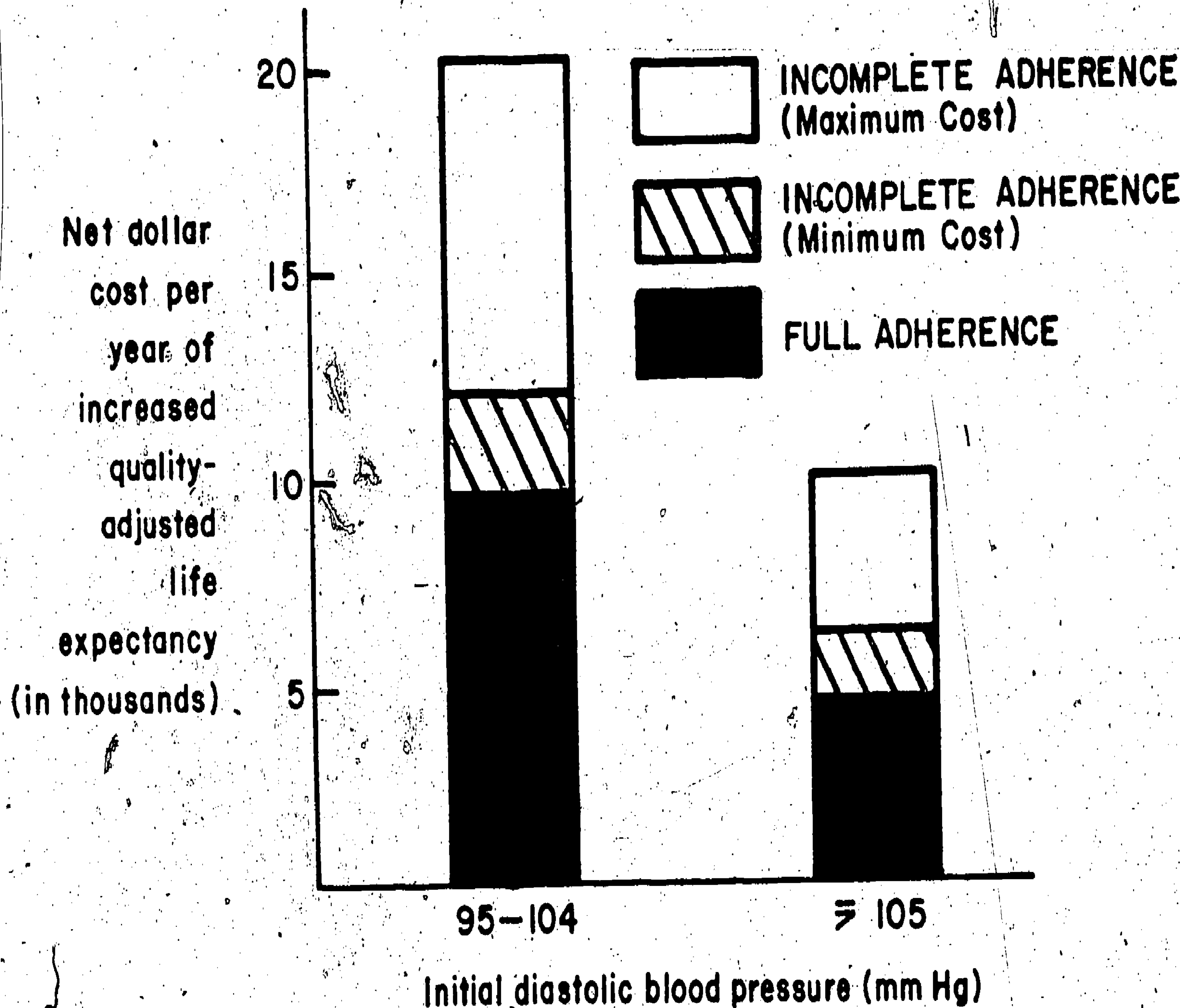

Figure 3. Impact of incomplete adherence and pretreatment blood pressure level on cost-effectiveness of treatment. Results are for 40 year olds.

TOXIC COMPOUNDS IN INDUSTRY

Principles and Practices of Industrial Air Standards

Trent R. Lewis, PhD

INTRODUCTION

In discussing toxic substances in industry, I believe it is important to familiarize each of you with the nature of two of the organizations in the United States that evaluate toxicologic, clinical, and epidemiological data and recommend industrial air standards. These are the National Institute for Occupational Safety and Health (NIOSH) in the Department of Health, Education, and Welfare and the Threshold Limit Values Committee of the American Conference of Governmental Industrial Hygienists (ACGIH).

Private organizations, other than ACGIH, such as the American Industrial Hygiene Association (AIHA), American National Standards Institute (ANSI), and the American Society for Testing and Materials (ASTM), have also made valuable contributions to occupational safety and health guidelines. Time limitations preclude a detailed discussion of their respective activities. It should be noted, however, that each recommended standard of the ASTM Committee on Occupational Health and Safety Aspects of Materials, Physical and Biological Agents, contains a thorough review of the literature on which that standard is based.

1

NIOSH/OSHA

NIOSH was established under the Occupational Safety and Health Act of 1970 (the Act) with four main responsibilities. These are:

1. the conduct of occupational health and safety research for new and improved standards,
2. the transmission of recommended standards to the Occupational Safety and Health Administration.

3. the furnishing of technical assistance to employers, employees, and others in the occupational safety and health fields, and
4. the development of an adequate supply of health and safety professionals to carry out the Act.

OSHA, also established under the Act, has the responsibility for

1. promulgating standards,
2. enforcing standards,
3. operating a national recordkeeping and reporting system,
4. providing employer/employee education, and
5. interfacing with state regulation of employment activities.

While NIOSH and OSHA have distinct specific responsibilities under the Act, it should be pointed out that each has a supportive role in several of the other's activities. One important difference in responsibilities is that NIOSH does not have the authority to issue citations, warnings, or fines, even if employers are in violation of OSHA regulations. NIOSH can only recommend corrective actions to the Department of Labor. NIOSH must, however, notify OSHA and affected workers in cases where imminent danger is discovered.

At the time of the preparation of this presentation (8/15/77), NIOSH had transmitted more than 60 criteria documents to OSHA. These criteria documents address the degree of hazard (including an environmental limit for worker exposure), provide procedures for monitoring worker exposure, and stipulate control measures to be taken for the physical agent, chemical, class of chemicals, or industrial processes addressed. Furthermore, NIOSH has developed, under a joint effort with OSHA, draft technical standards for most of the consensus health standards contained in Section 1910.1000 of Title 29 of the U.S. Code of Federal Regulations. The consensus health standards consist of the 400-plus Threshold Limit Values (TLVs) in the ACGIH 1968 list and the several ANSI Standards (22) adopted by OSHA in 1971 to rapidly implement the Act. The draft technical standards developed by NIOSH/OSHA in their Standards Completion Program include, in addition to the numerical air standards, provisions for

1. informing the employee of potential hazards;
2. monitoring techniques,

3. engineering and control mechanisms,
4. medical surveillance programs, and
5. fire and other safety hazard evaluations.

ACGIH TLV COMMITTEE

The ACGIH TLV Committee was a pioneer and prime contributor to the establishment of safe industrial exposure limits. This endeavor was initiated during World War II and has continued with the publication of annual lists which are continually revised and added to. Over 600 substances of industrial interest appear in the 1976 TLV booklet (1). Until August 27, 1971, the day of promulgation of the 1968 TLVs into Federal standards by OSHA, the TLVs served only as recommended limits of good industrial hygiene practice and were used as guidelines by various states (sometimes with force and effect of law) and industries within the states. On August 27, 1971, the Department of Labor promulgated the 1968 TLVs as Federal Standards with which all industry must comply.

TLV CONCEPTS

The first category of TLVs represents, with certain exceptions, time-weighted average (TWA) concentrations of airborne substances associated with industrial operations and manufacture designed to protect the health and well-being of nearly all workers repeatedly exposed during a 7- or 8-hour workday and 40-hour workweek, not only for their working lifetime, but also after retirement. Because of wide variation in individual susceptibility, however, a small percentage of workers may experience discomfort from some substances at low concentrations at or below the threshold limit; a smaller (very low) percentage may be affected more seriously by aggravation of a preexisting condition or by development of an occupational illness (2). One means of improving the coverage of the TLVs would be tests to detect those individuals hypersusceptible to industrial chemicals to which they may be exposed.

TWAs (1) permit excursions above the limit provided there is compensation in the extent of exposure by equivalent deviations below the limit during the workday. The degree of permissible excursion for a particular substance is related to the numerical value of the TLV-TWA.

A second category of TLVs are those designated with a ceiling value, i.e., a maximum value that should not be exceeded. There are 36 substances with a ceiling (C) value in the 1976 booklet (1). Ceiling values are placed on substances essentially fast-acting in nature.

A third category of TLVs, one added in 1976, is the Short Term Exposure Limit (STEL)--the maximum concentration to which workers can be exposed for a period up to 15 minutes continuously without suffering from

1. intolerable irritation,
2. chronic or irreversible tissue change, or
3. narcosis of sufficient degree to increase accident proneness, impair self-rescue, or materially reduce work efficiency.

In addition, no more than four excursions per day are permitted, with at least 60 minutes between periods, and the TLV-TWA cannot be exceeded.

The TLVs are intended for use in the practice of industrial hygiene and should be interpreted and applied only by a person in this discipline. They are not intended for use, or for modification for use,

1. as a relative index of hazard or toxicity,
2. in the evaluation or control of community air pollution nuisances,
3. in estimating the toxic potential of continuous, uninterrupted exposures or workshifts differing from the 5-day per week, 8-hour per day, 40-hour per workweek.
4. as proof or disproof for an existing disease or physical condition, or
5. for adoption ~~by~~ countries whose working conditions differ from those in the United States of America, and where substances and processes differ.

OPERATIONAL PRACTICES

Where two or more organizations recommend air limits, what should be done if their recommendations differ? The long-term approach is to await the promulgating action of OSHA following public hearing and the weighing of the respective evidence for each recommended limit. The more immediate approach is to carefully examine the toxicologic information, economic impact, and factors relating to exposure control to arrive at a carefully considered decision of the limit you wish to apply, remembering that you must comply with existing Federal standards. The differences in the limits recommended usually reflect differing interpretations of the knowledge at hand. When NIOSH limits are different from others, they tend to be lower and reflect its statutory mandate to recommend standards that protect the health and safety of all members of the workforce at all times.

Special policies are applied in evaluating those substances used industrially that have proven carcinogenic in man, or have induced cancers in animals under appropriate experimental conditions. Governmental policy makers operate under the premise that the state of the art of carcinogenic etiology and control is insufficient to define safe exposure levels. Thus, in practice, permissible exposures to carcinogenic substances must be the minimum feasible exposure limit.

BIOLOGIC THRESHOLD LIMITS

A second means of monitoring and controlling worker exposure in addition to environmental air monitoring, is the utilization of biologic threshold limits. Such limits have been utilized for a number of years in the lead industry and are recognized by medical and legal professionals as indices of overexposure. The unique features of biologic values are they measure the worker's overall exposure and they measure the worker's individual and characteristic response to the toxic agent. These measurements of response furnish an assessment of toxic insult and consist of

1. changes in amount of some critical biochemical constituents,
2. changes in activity of a critical enzyme, or
3. changes in a physiologic function.

Determination of a worker's exposure to a substance, or the biologic values, may be made by

1. analysis of blood, urine, hair, nails, tissues, and fluids for the substance,

2. analysis of tissues and fluids to determine the metabolite or metabolites of the substance, and
3. analysis of the exhaled breath to determine the concentration of the substance.

Biologic measurements furnish two types of information: an index of exposure and an index of response. Major difficulties in establishing biologic threshold limits are the difficulty in establishing norms due to individual differences among workers, the greater difficulties in developing sampling and analytical methods, and variables such as functional derangements in the organs of metabolism and excretion and metabolic interactions with drugs. In addition, biologic monitoring has very limited applications for assessing carcinogenic response to industrial chemicals. Biologic monitoring and environmental air monitoring are utilized as complementary means of addressing worker exposure and protecting his health.

PROBLEMS OF DATA ACQUISITION

One of the greatest problems facing standards developers, e.g., NIOSH, OSHA, and the TLV Committee of ACGIH, is the acquisition of appropriate data. This is a major, but not the sole, factor why only 24 or so new limits are established yearly, although several hundred new products are placed on the market annually. It is paramount to remember that industrial air standards or limits are values for industry. However, industry in general does not develop anywhere near enough kinds and amounts of data on its own products. This is unfortunate. Since the state and Federal governments are not in a position to provide qualified manpower and accessible facilities to handle this problem in toto, nor should they, a major portion of the burden of toxicologic assessment of its articles of commerce must be borne by industries. It does have recourse, though they be a limited resource, to reliable toxicology consultants and laboratories in the private sector to address such endeavors.

As the last portion of my presentation, suggested sources of information on industrial toxicology are appended along with suggested sources for ready referral as follows:

Given these low levels, we cannot prove that fibrous glass does not produce disease. We can only show that at low levels, disease does or does not appear. We cannot say what might happen at other levels of exposure, or with exposure under a different set of conditions. For fibrous glass, this happens to be an important question. Of particular interest is the question whether the inhalation of glass fibers produces lung cancer.

On the other hand, what we can do with epidemiologic studies of working populations is demonstrate whether there is or is not an increased risk of disease in man under conditions which prevailed in the past. If we cannot find an excess in a well designed investigation, it seems ethically and morally responsible to assume that, despite any other evidence, an increased risk does not exist. That does not say anything conclusive about the substance with which we are dealing, or whether it might not under some other conditions pose a hazard to man's health.

I hope you will agree epidemiology is common sense. On the other hand, the application of epidemiologic techniques does require, in my opinion, special training if epidemiologic evidence is to be believable.

OCCUPATIONAL SAFETY AND HEALTH

Selected List of Informational Sources

1. Referral Services

National Referral Center for Science and Technology, Library of Congress, Washington, DC 20540

Science Information Exchange, Smithsonian Institute, 1730 M Street, NW, Washington, DC 20036

2. Government Agencies

Bureau of Mines, Department of Interior, 4800 Forbes Avenue, Pittsburgh, PA 15213

Environmental Protection Agency, 401 M Street, SW, Washington DC 20460

Federal Regional Offices (10), NIOSH, OSHA

Region I-Boston, MA	Region VI-Dallas, TX
Region II-New York, NY	Region VII-Kansas City, MO
Region III-Philadelphia, PA	Region VIII-Denver, CO
Region IV-Atlanta, GA	Region IX-San Francisco, CA
Region V-Chicago, IL	Region X-Seattle, WA

National Institute for Occupational Safety and Health, DHEW, Danac Building, 5600 Fishers Lane, Rockville, MD 20857

Occupational Safety and Health Administration, DOL, 200 Constitution Avenue, NW, Washington, DC 20210

State and local Occupational Safety and Health Units (Health Departments, Labor Departments, Industrial Commissions, Department of Labor and Industry; also State Regional, County and City Offices)

3. Associations and Organizations

American Conference of Governmental Industrial Hygienists, P.O. Box 1937, Cincinnati, OH 45201

American Industrial Hygiene Association, 66 South Miller Road, Akron, OH 44313

Information Sources

American Insurance Association, Engineering & Safety Department, 85 John Street, New York, NY 10038

American National Standards Institute, 10 E. 40th Street, New York, NY 10016

American Public Health Association, 1015 Eighteenth Street, NW, Washington, DC 20036

American Society for Testing & Materials, 1916 Race Street, Philadelphia, PA 19103

Department of Environmental, Public, and Occupational Health, American Medical Association, 535 North Dearborn Street, Chicago, IL 60610

Industrial Health Foundation, 5231 Centre Avenue, Pittsburgh, PA 15232

Manufacturing Chemists Association, Inc., 1825 Connecticut Avenue, NW, Washington, DC 20009

National Fire Protection Association, 60 Batterymarch Street, Boston, MA 02110

National Safety Council, 444 N. Michigan Avenue, Chicago, IL 60611

4. Journals and Periodicals

American Industrial Hygiene Association Journal (monthly), 66 South Miller Road, Akron, OH 44313

Annals of Occupational Hygiene (quarterly), Pergamon Press, Maxwell House, Fairview Park, Elmsford, NY 10523

Archives of Dermatology (monthly), Circulation Department, American Medical Association, 535 North Dearborn Street, Chicago, IL 60610

Archives of Environmental Health, Heldref Publications, 4000 Albemarle Street, NW, Washington, DC 20016

Atmospheric Environment (monthly), Pergamon Press, Maxwell House, Fairview Park, Elmsford, NY 10523

Bulletin of Hygiene (monthly), Keppel Street, London, England WC1E 7HT

Chemical Reviews (bimonthly), American Chemical Society, 20th and Northampton Streets, Easton, PA 18042

Industrial Hygiene Digest (monthly), Industrial Health Foundation, 5231 Centre Avenue, Pittsburgh, PA 15232

Information Sources

Journal of the Acoustical Society of America (monthly), American Institute of Physics, 335 E. 45th Street, New York, NY 10017

Journal of the Air Pollution Control Association (monthly), APCA, 440 Fifth Avenue, Pittsburgh, PA 15213

Journal of Hygiene (quarterly), 32 E. 57th Street, New York, NY 10022

Journal of Occupational Medicine (monthly), published for American Occupational Medical Association, Mayo Publications, 1007 Burlington Avenue, Downers Grove, IL 60515

Modern Plastics (monthly), (Annual Encyclopedia Issue included in subscription rates), McGraw-Hill, Inc., 330 W. 42nd Street, New York, N.Y. 10036

National Safety News (monthly), National Safety Council, 444 N. Michigan Avenue, Chicago, IL 60611

Occupational Health Review (quarterly), Occupational Health Division, Department of National Health and Welfare, Ottawa, Canada

Occupational Hazards (monthly), The Industrial Publishing Corporation, 614 Superior Avenue, West Cleveland, OH 49113

Occupational Safety and Health (monthly), The Royal Society for Prevention of Accidents, 6 Buckingham Place, London, SW1E 6HR

Safety Standards (bimonthly), OSHA publication. Available from Superintendent of Documents, GPO, Washington, DC 20402

5. Reference Texts

Air Sampling Instruments--for Evaluation of Atmospheric Contaminants. 5th Edition. 1977. American Conference of Governmental Industrial Hygienists

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Dorland's Illustrated Medical Dictionary, 25th Edition. 1974. W. B. Saunders Company, Philadelphia

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Meidl, H. H. 1970. Flammable Hazardous Materials. Glencoe Press, Beverly Hills

Methods of Air Sampling and Analysis. 1972. American Public Health Association, Washington

Accident Prevention Manual for Industrial Operations, 6th Edition. 1969. National Safety Council, Chicago

Fundamentals of Industrial Hygiene. 1970. National Safety Council, Chicago

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Sax, N. I. 1968. Dangerous Properties of Industrial Materials. Reinhold Publishing Company, New York

Schwartz, L., et al. 1961. Occupational Diseases of the Skin, 3rd Edition. Lea & Febiger, Philadelphia

Stecher, P. G., Ed. 1968. The Merck Index of Chemicals & Drugs, 8th Ed. Merck & Company, Ind. Rahway, N.J.

von Oettinger, W. F. 1963. Poisoning--A Guide to Clinical Diagnosis and Treatment, 2nd Ed. W. B. Saunders Company, Philadelphia

Weast, R. C. 1972. CRC Handbook of Chemistry and Physics, 52nd Ed. Chemical Rubber Company, Cleveland

Zimmerman, O. T. and I. Lavine. 1953. Handbook of Material Trade Names. And Supplements I, II, III, IV. Industrial Research Service, Inc. Dover, N. H.

6. Abstracts and Indices (Periodical Literature)

Applied Science & Technology Index, 1958. (Formerly the Industrial Arts Index, 1957.) (monthly, quarterly and annual-cumulative) H. H. Wilson Company, New York

Chemical Abstracts (Toxicology, Air Pollution and Industrial Hygiene), (biweekly). The American Chemical Society, Easton, PA

Index Medicus. National Library of Medicine (monthly). U.S. Department of Health, Education, and Welfare, Public Health Service, Superintendent of Documents, U.S. Government Printing Office, Washington

Industrial Hygiene Digest (Monthly). Industrial Health Foundation, Mellon Institute, Pittsburgh, PA

INFORMATIONAL SOURCES ON THE TLVs of the
AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS
DEVELOPMENT OF REQUISITE DATA -- TLV COMMITTEE ACTIVITIES
PROBLEMS IN SETTING TLVs

Available from Dr. Trent R. Lewis
National Institute for Occupational Safety and Health
4676 Columbia Parkway
Cincinnati, OH 45226

1. Criteria and Procedures for Assessing the Toxic Responses to Industrial Chemicals, ACGIH, TLV Committee
2. Current Problems of Setting Occupational Exposure Standards. 1969. Arch Environ. Health 19:277
3. Development of TLVs for Fibrous Materials. 1969. Presented at the American Industrial Hygiene Association Conference. Denver
4. Documentation of the TLVs for Industrial Air, III Ed, 4th Printing. 1977. ($20)
5. Industrial contribution to threshold limit values. 1965. Arch Environ Health 10:609
6. Modus operandi of threshold limits committee of ACGIH. 1964. Am. Ind. Hyg. Assn. J. 25:589
7. Preface to TLV Booklet (TLV Bookles $1.50)
8. Principles and Procedures for Developing Data from Human Subjects for Industrial Air Limits. ACGIH, TLV Committee
9. Principles and Procedures for Developing Experimental Animal Data for Threshold Limit Values for Air. American Conference of Governmental Hygienists, Threshold Limit Values Committee, Cincinnati, OH
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TOXIC COMPOUNDS IN INDUSTRY

Perspectives on Current
Occupational Medical Practice

Irving R. Tabershaw, MD

Occupational medicine is developing rapidly in a milieu which is quite different from that of even two years ago, and markedly different from seven years ago when the Occupational Safety and Health Act (the Act) was passed. While the Act specifically affects occupational medicine, it is only one of the many laws which in the last two decades are stimulating and mirroring a change in social policy which goes well beyond the practice of worker health. Our society is demanding that industry examines and accept responsibility for the effect of its activities on the health of its workers, on the community, on the users of its products, and on the environment.

Many laws concerning potential adverse effects on health because of exposure to noxious agents during industrial activities were amended several times in the last two decades. The Clean Air Act has been amended six times since its original passage in 1953; the Federal Water Pollution Control Act of 1952 has been amended eight times; and the Food, Drug and Cosmetic Act of 1938, 20 times, the latest being in 1976. I will not burden you with other laws and amendments, except to mention three noted as landmark legislation: the Federal Coal Mine Health and Safety Act of 1969, the OSHAct of 1970, and the Toxic Substances Control Act of 1976.

The government agencies which set standards and enforce compliance under these laws impact directly on health practices of industry and particularly on the chemical sector. But even more significant than the scope of these activities is the increasingly rigid interpretation of the intent of the law by the administrators in the agencies responsible for regulation and enforcement.

The total effect is to develop in the American public and in its workers an awareness, and now it seems a national belief, that if an accident or an illness at work occurs, someone is at fault.

It is either a negligent or malevolent act of some person or organization, often a profit making company, or failure on the part of legislators to pass a law to cover the situation, or the ineptness of enforcement on the part of the regulatory agencies. There is an increasing intolerance by the public to accept an explanation of ignorance, or inadequate information, or "an act of God" for any adverse health effect which can be attributed to the occupational environment.

Industry is responding, albeit irregularly and unevenly, to this social policy that it be held accountable for environmental or occupational health. It is adopting in major companies a policy similar to the one it has regarding the management of money; that is, it is appointing competent executives and providing them with the skills and disciplines necessary to identify and control potential hazards. It is also developing an internal information system which will permit proper and timely decisions about health. This acquisition of the pertinent skills and disciplines, and the restructuring of the company's bureaucracy and administration to integrate these disciplines in the corporate matrix, toxicology, industrial hygiene, environmental engineering, occupational medicine, regulatory affairs, and so forth, is taking place rapidly.

The most difficult discipline to incorporate into the industrial framework is medicine. Some patterns and experiences for the integration of full-time physicians are available, but the proper relationship of corporate staff and policy to the part-time or on-call physician serving the smaller units of a corporation presents administrative, logistic, and professional difficulties.

These difficulties in providing adequate occupational health services to the smaller plant have always existed, but they have taken on a new importance. Heretofore, they could be left to the local plant management to muddle along with whatever medical care was available in the community. However, in the present social climate, adverse health publicity reflects on the parent corporation both financially and publicly, and in some instances, may threaten the very existence of the corporation.

The impact of the changed legislative and social structure is equally great on the general practitioner or the part-time plant physician serving industry, whose work takes on a new demension and responsibility. For instance, it is difficult in a private, group, or hospital practice to be certain that medical information is kept confidential, that patients have access to their records when needed, and that informed consent has been obtained when necessary.

It is even more difficult to accomplish these objectives when carrying out a diagnostic or therapeutic procedure in the work situation, and at the same time conform to the legislative and regulatory demands of OSHA, EPA, FDA, and so forth, to keep management appropriately informed, and to retain the confidence and trust of the worker and union.

Nevertheless, occupational medicine is a growing field, for the diverse health effects which can result from the massing of modern technology is at last being appreciated. Even were it not regulated, occupational medicine would offer a fertile challenge to the medical practitioner. The industrial chemical revolution is less than two centuries old, and the changes it induces in individuals and in whole populations are still evolving. Many are being recognized for the first time.

Although OSHA has been in existence for six years, the full effect on medical practice has not yet been realized because first years were concerned mostly with safety matters. During the last two years attention has been shifted to health, and some 40 criteria documents, reviews of the current status of knowledge of the relationship of a known industrial toxin to environmental levels, have been issued. These are compendia of published literature on specific toxins in industry and form an excellent library. OSHA has formally promulgated only four standards: asbestos, vinyl chloride, 14 carcinogens, and coke oven emissions, and is currently proposing two other standards, benzene and beryllium. It will be illustrative and informative to concentrate on medical aspects of the proposed benzene standard, which encompasses the background and problems currently extant in occupational toxicology.

Benzene, a major solvent, feedstock, and fuel, has been recognized as a toxic substance for more than three-quarters of a century. The primary route of entry is inhalation, although there is some skin absorption. Exposure to high concentrations affects the central nervous system producing narcosis, coma, and death. Lesser amounts can produce nervous excitation, headache, euphoria, and nervous irritability, and lower concentrations produce vertigo, drowsiness, headache, and nausea. These acute effects are easily recognized and controlled.

Benzene inhaled in smaller amounts over a longer period of time exerts a toxic effect on the bone marrow. The clinical indications are essentially those of cytopenia, anemia, leukopenia, and thrombocytopenia. If exposure continues, depression of the bone marrow with aplastic anemia is produced. The clinical signs and symptoms are expressions of the cytopenia and numerous blood dyscrasias involving one or a number of these elements have been described. Death from aplastic anemia was common in years past.

The threshold limit value time weighted average (TWA), that is, the concentration of benzene that may be inhaled in a workplace without deleterious effect over a 40-hour week and a lifetime of exposure, has been reduced progressively from 100 ppm in 1941 and is currently at 10 ppm with a 25 ppm ceiling. The present standard does not mandate biological monitoring:

1941	100 ppm*	Maximum Allowable Concentration
1947	50 ppm	8-hour Time Weighted Average
1948	35 ppm	8-hour Time Weighted Average
1957	25 ppm	8-hour Time Weighted Average
1963	25 ppm	25-ppm Ceiling
1969	10 ppm	8-hour Time Weighted Average (ANSI)
1971	10 ppm	8-hour Time Weighted Average (OSHA)
1977	1 ppm*	8-hour Time Weighted Average (OSHA) - EMERGENCY STANDARD

* ppm = parts per million; 1 ppm = 0.0001%

The standard proposed by OSHA will reduce the allowable level to 1 ppm and a 5-minute ceiling sample and will buttress this standard with medical surveillance.

The reduction of the proposed standard is not based on evidence that disease has occurred at the 1 ppm level, but rather that benzene has been judged by NIOSH and OSHA to be a carcinogen.

It is administrative policy that all carcinogens be maintained at the lowest possible level for regulatory purposes. For benzene, this has been determined to be 1 ppm, a level which is only slightly higher than benzene air concentration which occurs naturally in some environments. The evidence for the leukemogenecity of benzene is a number of epidemiologic reports, mostly in the European literature, and a recent study by NIOSH which has been demonstrated to have many flaws.

All these epidemiologic studies have grave deficiencies, and since leukemia has not been induced in animals with benzene, even though animal models for induction of leukemia exist, it is questionable that benzene is a true carcinogen rather than a suspect carcinogen. Nevertheless, OSHA proposes to reduce the standard to 1 ppm, when all substantial evidence indicates that any cytopenia occurs at 25 ppm or above, with a safety factor of 10, and is reversible if the individual is removed from exposure and not re-exposed.

Whether or not it makes the air concentration more restrictive, OSHA proposes that medical surveillance be established. Since they estimate that anywhere between 200 thousand and 2 million workers are exposed to benzene, the medical profession will have to provide this surveillance, based upon the requirements of OSHA.

The proposed standard states that the medical surveillance program consists of:

"1. A history which includes past work exposures to benzene or any other hematologic toxins, a family history of hematological neoplasms, a history of blood dyscrasias including genetically related hemoglobin alterations, bleeding abnormalities, abnormal function of formed blood elements, a history of renal or liver dysfunction, a history of drugs routinely taken, alcoholic intake and systemic infections.
2. A complete blood count including a differential white blood cell count.
3. Additional tests shall be conducted where, in the opinion of the examining physician, alterations in the components of the blood are related to benzene exposure.
4. All medical procedures shall be performed by or under the supervision of a licensed physician, and shall be provided by the employer without cost to the employee.
5. Medical surveillance and testing of each employee shall be conducted within thirty days of the effective date of this action, and quarterly thereafter. If an employee is accidently or otherwise exposed to benzene by ingestion,

inhalation, skin or eye contact, or for any reason, an employee develops signs and symptoms commonly associated with exposure to benzene, the employer shall provide appropriate medical examinations and emergency treatment."

The history and physical examination offers no problem. All physicians who have had experience with benzene agree the blood count is vital in determining earliest effects of benzene exposure, the first findings being a mild anemia and a macrocytosis which are reversible. Also, the blood count should include a white count and differential to be carried out at least annually.

The provision for additional tests does raise questions of scope and content, since there are no clinical laboratory tests which are specific for benzene. NIOSH recommends phenol in urine, reticulocyte and platelet count, and serum bilirubin levels. It is questionable whether these offer more than a complete, careful blood count.

The proposed regulations, and this is true of all the standards, demand that the employer inform the plant physician about the regulation, the duties of the worker, and worker exposure. It also obligates the physician to write an opinion on the results of his medical findings, whether or not the employee would be at risk, and any limits to employment.

The medical program carried out by the plant physician would depend on the physician's knowledge, acumen, and understanding of what is necessary, desirable, cost/effective, feasible, and practical to protect the worker. The physician must understand the toxicologic properties of benzene and relate the program to the use of benzene and the hazard it poses to the worker in the plant.

The plant physician must respond not only to the medical problems presented by the workers, but do so within the requirements of OSHA regulations. These may or may not be in harmony with the plant physician's viewpoint. Moreover, should OSHA adopt 1 ppm as the standard, the physician will have to do many needless examinations, since no effect has been demonstrated in any human being or animal below 25 ppm.

It is likely these medical requirements will never be changed by the regulatory agencies. Perhaps the most damaging aspect of the rigid medical requirements is that once established, the physician will be unable to exercise his medical judgment or apply his time, effort, and concern to the welfare of his patients, where he believes it is most needed. Finally, any abnormalities of blood counts and liver and kidney functions which turn up will have to be interpreted in the face of vague OSHA regulations regarding medical restrictions.

The proposed standard, if passed, places new responsibility for worker health on the physician, because the social climate demands the physician be accountable for his actions to a regulatory agency. Industrial toxins will be controlled better, and adverse health effects will be recognized earlier and many prevented, but not without a great waste of time, effort, and physician manpower.

TOXIC COMPOUNDS IN INDUSTRY

Epidemiology in Studies of Occupational Health

Philip E. Enterline, PhD

Recently someone asked the head of the Bureau of Epidemiology of a large government regulatory agency what was epidemiology and an epidemiologist? He said, "Epidemiology is nothing more than common sense and statistics. We don't need any special training." That was an interesting response, and I'd like to explore with you the extent to which it is true.

More formally, epidemiology is a study of the distribution and the determinants of diseases in man. I want to underscore that last word "man," because this is what distinguishes epidemiology from other scientific efforts relating to cause and effect. Generally, it's not possible to experiment with man in the same way as with animals, so we must be satisfied to observe man within his environment. Essentially, we do not manipulate man; rather, man manipulates himself and the epidemiologist observes what happens.

Now I would not disagree that epidemiology is common sense, and I would hope most disciplines include an element of common sense. In 1854 there was a cholera epidemic in London and a physician named John Snow made some observations. To us they might seem like common sense observations, but at the time no others had made them. He observed the London epidemic was confined largely to people who purchased their water from one of the two water companies that served London. These two companies were in competition; one difference between them was one water company drew its water from the Thames below the city of London, where it was quite polluted, and the other company drew water upstream of London, where the water was cleaner and didn't contain London's sewage.

Snow observed that people who drank water from the company drawing from the polluted area of the river had a cholera death rate of 5 per 1,000 in the year 1854. By contrast, those people who drank water drawn upstream of London had a death rate of less than 1 per

1,000, a five-fold difference. Formally, epidemiologists call this the Method of Difference, and that seems like common sense. The difference had something to do with the water quality, and this made sense in the context of John Snow's observations.

Snow also found a section of the city where people could draw from one water company or the other. The water companies in some parts of London competed head on--they had pipes going down the same street, so that one might choose to buy from one company or the other. He studied those sections of London separately and noted the cholera death rate in these sections was just halfway between the death rate of sections of London that had clean water and that of sections that had dirty water. He compiled a table showing that in what we'll call the dirty water section, death rates were 5 per 1,000 in the mixed, half dirty - half clean section, 2.2 per 1,000; and in the unpolluted section, with people drawing water from the non-polluted section, about 1 per 1,000, a definite variation. Epidemiologists would call that, the Method of Concomitant Variation. It means that the more of what you believe to be the agent is present, the greater is the response. That's a level of epidemiological evidence, and it is also common sense.

Finally, Snow verified all these observations by looking at a single street where he noted two factories. One factory was making percussion caps, employed 200 workers, and in a single year had 18 deaths from cholera. The other was a brewery that employed 70 workers and had no deaths. He talked to some people about the brewery workers, and he said about one, "Mr. Higgens believes that these men don't drink water at all."

This is a form of replication. If one finds the same thing over and over again, there seems to be an element of truth that would not be present if one observed it once but did not observe it under any other condition.

So there are three methods, the Method of Difference, Method of Concomitant Variation, and the phenomenon of Replication. They all involve common sense. Another thing: John Snow didn't know what the agent was that caused cholera, but by using these methods, he figured out how to stop the epidemic: by changing the water supply, the incidence of cholera could be modified.

Now I would like to project this idea into the cancer problem. This does not seem as simple as the cholera problem, with disease following exposure and a short incubation period. Rather, we may have long exposure and a long incubation period with appearance of the disease much later, perhaps 20, 30, or even 40 years later. This poses serious logistical problems in conducting epidemiologic studies, and I would like to illustrate them.

Figure 1 shows that it takes a long time for cancer to appear. It also shows something else, that the pattern of appearance is fairly predictable. The figure demonstrates the incidence of leukemia following the explosion of the atomic bombs at Hiroshima and Nagasaki in 1945. Note there was some excess of leukemia in 1946, but not much above what might have been expected. There was a peak incidence of leukemia somewhere after 1950. Then the incidence began to decline, and after about 20 years or so, it fell back to normal.

This illustrates how a single exposure to radiation might affect the incidence of the disease. Not everybody got the disease right away, some people got it sooner than others, but there was a kind of modal period...a period when more people got it than in any other period.

The distribution of leukemia cases was close to a mathematical function called a "log normal distribution," which is shown in Figure 2, which represents exposure to a single dose of asbestos and the time to appearance of a tumor. Here, the mediam time is 24 years, but it is possible for some cases to show up within 6 years. It is also possible for some cases not to show up until 60 years. We fitted the log normal curve to a lot of data, and it seemed to be a pretty good predictor. If one knows the mathematical function that describes some phenomenon, it is very useful in research terms.

Figure 3 adds another dimension, and that is the fact the time it takes for a tumor to appear is dependent upon the intensity of the dose. For a very mild dose, the tumor might not appear for a very long time. For a very severe dose, the tumor might appear rather quickly. The figure shows a series of log normal curves. These incorporate two additional ideas. The first idea is that the <u>amount</u> of disease is directly related to the dose. We say this is

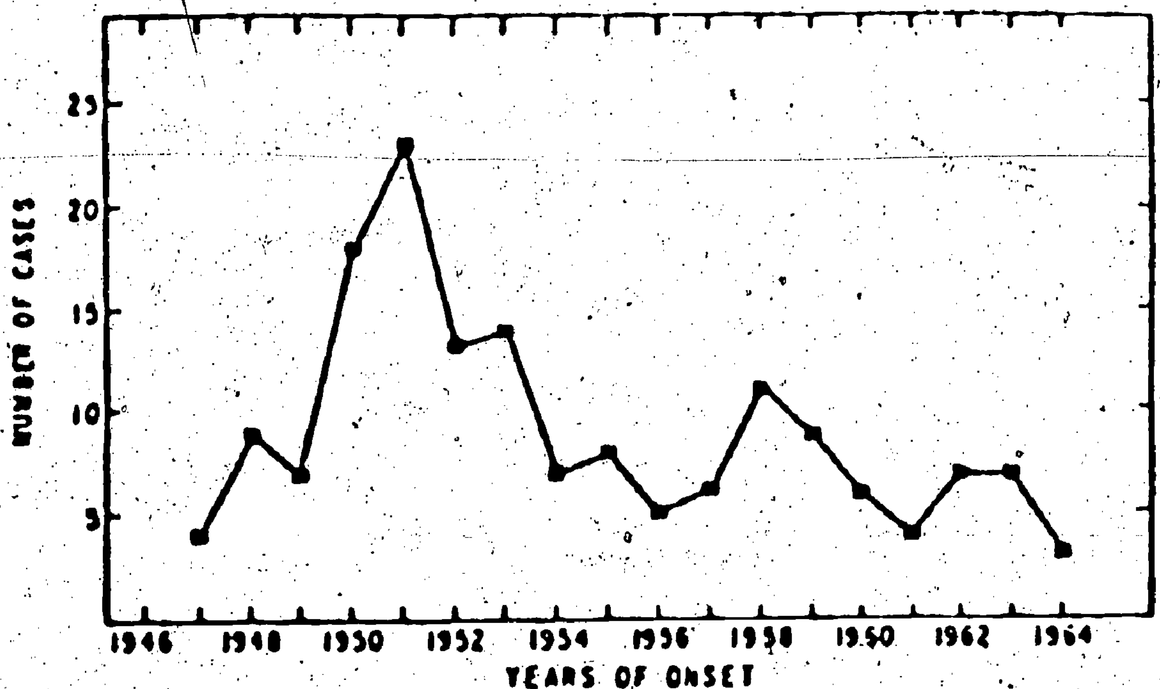

Figure 1. Incidence of leukemia at Hiroshima and Nagasaki

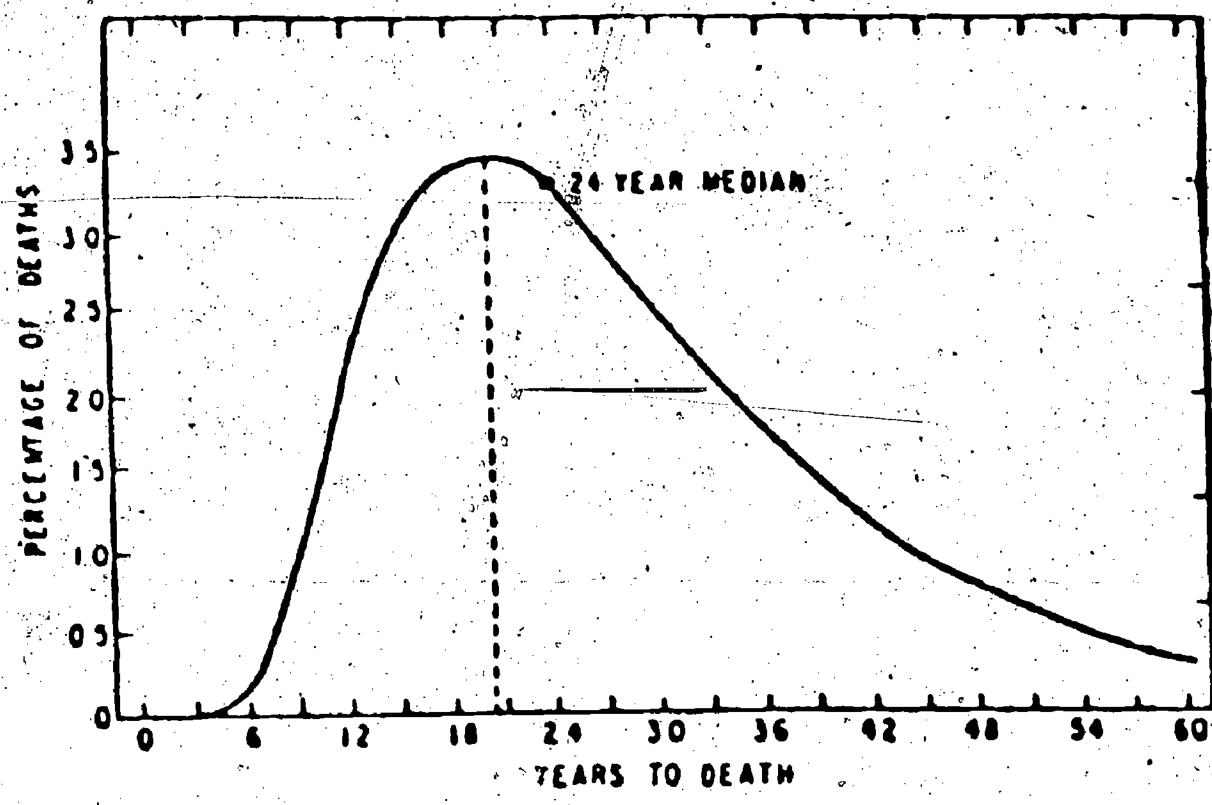

Figure 2. Respiratory cancer resulting from a single exposure to asbestos.

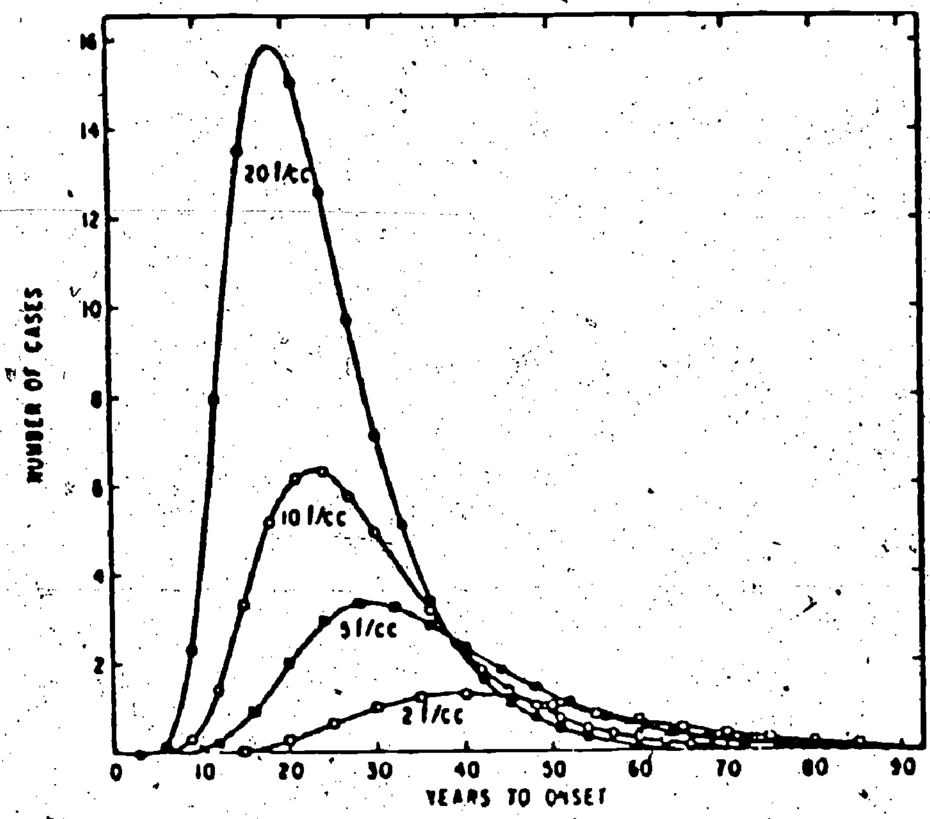

Figure 3. Respiratory cancer resulting from single asbestos exposure at 4 level.

a simple direct linear relationship. Secondly, the <u>time</u> to tumor is a function of dose. This was discovered about 1967, and it appears the function is one over the cube root of dose -- the inverse cube root of dose. In the asbestos example, then, for exposure to 1.5 fibers per cc, large numbers of tumor would show up after about 80 years, and some could appear as late as 120 or 140 years after the exposure.

The foregoing example is very theoretical, but the practical meaning is that not many people are going to be concerned about tumors that show up 80 years after the exposure, because they will not be around. But it adds another dimension to the business of setting threshold limit values, a warning that we might have to consider a dose level where the tumors would show up in 150 years. It is important to realize in studying the epidemiology of cancer that we may have long latent periods, determined to some extent by how intense the exposure is that we are investigating.

Returning to the Method of Difference, I began to get involved in industrial epidemiology 20 years ago, and some of the first data I received had to do with death rates in chromate workers and oil refinery workers as shown in Table 1.

Table 1. Lung cancer mortality experience for U.S. chromate workers* compared with oil refinery workers+

	Annual rate per 100,000	
	Age $\leq$ 50	Age $>$ 50
Chromate Workers (1930-47)	197	480
Oil Refinery Workers (1923-38)	5	22

*Based largely on group life insurance records in six plants - 11,019 man-years.

+From Machle and Gregorius, 1948

Here, we are dealing with deaths from lung cancer. One can see the magnitude of the difference is simply overwhelming. The chromate workers under 50 years old have a death rate of around 200 per 100,000, and the oil refinery workers had a death rate of 5, a forty-fold excess. It is almost as bad if one considers ages 50 years and over. This is a 1948 study, one of the early observations on industrial cancers.

The Method of Concomitant Variation is very important in occupational disease epidemiology. This involves working with industrial hygiene people to try to find out what were the different exposure levels. I think that is one thing very much lacking in many studies today and certainly in the old studies. There were no estimates of what the exposures were that caused the observed response.

Table 2 is from a study we did on asbestos workers. These people go back to the 1920s in terms of their exposure, to fairly high levels. The purpose here is to show there is a dose-response relationship, and the Method of Concomitant Variation suggests there is a cause and effect relationship.

Table 2. Relative risk for respiratory cancer among retired asbestos workers

Years since first exposure	Mean dust level 10 mppcf*	10 mppcf+*
Under 20	1.2	3.1
20 - 29	1.8	3.6
30 or more	2.8	4.7

* Millions of particles per cubic foot

Table 3. Observed and expected respiratory cancer deaths and standardized mortality ratios by intensity and duration of exposure

Intensity of exposure (µg/1 urine)	Duration of exposure: Under 25 years Obs	Exp	SMR	25 years and over Obs	Exp	SMR
50 - 199	2	2.1	95.2	10	3.6	277.8*
200 - 349	4	1.5	266.7	8	2.2	363.6*
350 and over	3	0.5	600.0*	5	0.6	833.3*

*P<.05

To demonstrate this with another subject. Table 3. (above) shows some data on smelter workers who were exposed to arsenic. Notice in the lower right hand corner the very high relative risk for people that had urinary arsenic levels of 350 or over, and who were exposed for a very long time. Here is very clear evidence of a dose-response relationship, whether we measure dose as the average intensity of exposure or as duration of exposure. In fact, there are almost perfect linear relationships, and either variable is a good predictor of the amount of disease that will be observed. Note the numbers are moving in a systematic way across this chart, from the upper left hand corner to the lower right corner.

A very important part of the epidemiologic method is to show there is a dose-response relationship. That has been one of the prime pieces of evidence on cigarette smoking, that the more you smoke, the higher is the risk of lung cancer. This is a very important leg upon which to base evidence of cause and effect relationships in any kind of population and particularly an industrial population.

Considering again the Method of Consistency, Table 4 shows results of all the epidemiologic studies that were done on asbestos in North America which could be compared. They all show an excess in relative risk. Unfortunately, all were done a little differently, and I had to do some correction of the data. In the last column, however, after making the corrections, we find all show the same thing--that the excess risks are high and not dissimilar.

Table 4. Relative risks and corrected relative risks for respiratory cancer for 6 studies, 20 years at entry since first exposure

Reference	Relative risk	Death certificate corrected +	Death rate corrected
Selikoff	9.2	7.6	6.2
Enterline	3.0	3.0	2.9
Cooper	7.8	7.8	6.7
Wagoner	2.8	2.8	3.6
Selikoff	8.2	6.8	5.5
Selikoff	5.8	4.7	4.7

Finally, a word about what cannot be done. One thing we cannot do with epidemiologic studies is prove an agent or substance does not cause disease. All we can do is find out whether there is an excess of the disease given the conditions under which workers are exposed. I am currently engaged in a study of the health of fibrous glass workers. Average concentrations of respirable fibers in fibrous glass production facilities are very low, below even the lowest of the government's proposals for exposures to fibers.

TOXIC COMPOUNDS IN INDUSTRY

Contributions of the Industrial Hygienist

Ralph G. Smith, PhD

The prevention of adverse health effects arising from occupational exposure to toxic compounds is certainly one of the major activities of the industrial hygienist, and may very well consume 90% of the time and effort expended for industrial hygiene activities in many organizations. It is imperative that the industrial hygienist be recognized as an essential member of a team of specialists concerned with occupational health and safety, and not operate in a world consisting only of air sampling pumps and OSHA standards.

The need for close working relationships with industrial physicians, nurses, safety specialists, and with increasing frequency, epidemiologists is great, and health and safety programs which operate as small autonomous units must be considered unsatisfactory. Having established this rather self-evident truth, let us briefly examine the industrial hygiene approach to dealing with toxic compounds as it has evolved to the present time.

Industrial hygiene is well defined as, "The recognition, evaluation and control of those environmental factors or stresses, arising in or from the work place, which may cause sickness, impaired health and well being, or significant discomfort and inefficiency among workers or among the citizens of the community" (1).

RECOGNITION

Although each of these activities is important, I believe the initial step of recognizing the potential for the existence of hazards due to toxic substances is of the greatest importance. It is frequently a routine matter to evaluate, by air sampling or other means, the magnitude of a hazard, and once measured, the control of the hazard may also be a routine engineering matter, but none of these activities will be initiated unless there is an awareness that a hazard may exist.

It is very important to establish whether or not the substances of interest can be expected to be present in the atmosphere as particulate suspensions, or as gases or vapors. Obviously the sampling technology will vary for each physical state, and on occasion it is difficult to make an exact prediction of the most probable physical state. Many compounds, particularly organic compounds of low or intermediate molecular weight, tend to have sufficient vapor pressure that although they may be disseminated as an aerosol, it is likely some of the substance will volatilize and be present as a vapor. If collection and analysis is limited to sampling by filtration, obviously the vapor portion will be lost.

For those substances which may exist in either the vapor or particulate phase, it will frequently be found that the permissible air concentration will be different for each physical state. Good examples of this phenomenon include the oil mist Threshold Limit Values (TLVs) and those for caprolactam. Experience has shown with the latter substance, for example, that the material is substantially more irritating when present as a fine dust suspension than when vaporized by the application of heat.

The personal monitoring devices normally give data which can be interpreted directly as time-weighted average exposure, thus making it a simple matter to determine the extent of compliance with standards which are expressed as time-weighted averages. It should be noted, however, that all time-weighted average exposure standards include provision for maximum excursions which may not be exceeded for more than specified periods of time. If it is suspected that higher concentrations may exist at any time during the work cycle, it then becomes necessary to sample by some other means to determine, for example, the 15-minute concentration which might be experienced.

In other cases standards are designated as "ceiling" values, or as short term levels of some kind that must not be exceeded. Clearly the long term measurements obtainable by the personal monitors are not always adequate for such measurements.

It is worthwhile to note that although personal monitoring is required by many federal standards, it is still useful on many occasions to perform what is generally designated as an area sampling, with a device maintained in a fixed location. A large lead and zinc smelter, for example, continues to monitor nearly 100 fixed points routinely, in addition to providing required personal monitoring evaluation, and the industrial hygienist believes much is learned by the fixed samplers, which would not be revealed by mobile samplers attached to workers. Specifically, it is possible to note that a given area is undergoing an upward trend, or that a sudden change in ambient lead concentrations, for example, has occurred. Such information may serve as a warning signal and lead to corrective actions before the situation worsens.

In relation to the measurement of short term concentrations of gases and vapors, it is attractive to use indicating tubes, and although there are many limitations to the use of such tubes, they are becoming more reliable and useful due to the improvement in quality resulting from the NIOSH certification program. It is now possible to use certified tubes and be reasonably confident that the results will fall within the limits permitted by the certifying agency. There is also growing use of the tubes for long-term sampling, whereby the worker wears a device which holds one or more tubes, through which air is drawn at a very low sampling rate for an extended period of time. Providing the appropriate calibration data are available from the supplier or from the user's own laboratory, such sampling may indeed be attractive due to its simplicity and direct read-out. There are still inherent limitations in the use of all indicator tubes, and care should be taken with respect to such variables as the age of the tubes, the presence of interfering substances, sensitivity, and so forth.

Even more attractive as sampling devices are the relatively new units generally referred to as passive samplers, which are designed to be worn as simple badges attached to the worker, and which are thereafter removed and analyzed by some appropriate means in the laboratory. There are at least two such kinds of devices currently on the market, both of which have recently been described (2,3), and which appear to be promising. The first device has been shown to give reliable data for sulfur dioxide and nitrogen dioxide and ought to be applicable to sampling organic vapors also. The second unit is specific for mercury, and in tests performed by NIOSH, proved to be surprisingly accurate for integrated measurements of mercury vapor. Undoubtedly the simplicity of such devices will encourage research efforts to increase their number, validity, and reliability. At present, however, it is probable that results obtained with such devices would not be considered adequate for demonstrating compliance with OSHA standards.

Another type of instrument useful in evaluating occupational exposure to toxic compounds is the continuous monitoring device, which is usually equipped with a recorder and/or alarm to alert those in the area to the presence of a potentially dangerous concentration of some gas or vapor. Such units are commonly found in areas where large quantities of hydrogen cyanide could be evolved, and are also useful in measuring carbon monoxide and other gases which have poor warning properties.

Once the air has been sampled and the substance of interest collected by suitable means, it is usually necessary that analyses be performed in the laboratory; although much analytical work has become routine, there are some problems of current concern. First, the concern with rather uncommon chemicals has challenged the analyst, and frequently it is difficult to devise a method which is suitably sensitive and specific for the chemicals present in the work room air. Another problem is posed by the government standard for "coal tar pitch volatiles," wherein the analysis is conducted for that portion of the sample which is soluble in benzene, rather than for active ingredients such as benzo-a-pyrene which may be responsible for the standard in the first place.

There is an increasing need for the analyst to adopt more sophisticated methods capable of differentiating different valence states of elements like arsenic and chromium. In the case of the proposed chromium standard, not only must the analyst limit analysis to hexavalent chromium, but also the solubility of the compound may be a factor in measuring the hazard. In other instances, a standard may vary if the substance is present as a fume rather than a dust, yet the analytical methodology for making this distinction is almost nonexistent.

A particularly troublesome problem is created when complex organic mixtures like most modern plastics are heated for extrusion or other purposes and thereby release a mixture of gases, vapors, and fumes about which relatively little may be known. The collection and analysis of these products is a subject about which much less is known than is desirable.

Finally, it should be noted that the requirements of modern standards are such that a great number of samples will be taken in the course of several years, and recordkeeping becomes a formidable problem.

It is probably essential that most organizations, particularly the larger ones, devise a system for storing basic air sampling data in such a way that it can be readily retrieved for future interpretation. In general, the data must be stored in at least two ways, the first relating to specific work operations and the second relating to individual workers. Many industrial hygiene organizations have evolved excellent systems and are finding them to be most convenient and useful.

Consideration should also be given to biological monitoring whenever applicable, in the recognition that air sampling is often limited in its ability to predict the true extent of absorption of toxic compounds in the work place. Then it is necessary to confer with medical and nursing personnel concerning the desirability of such employee testing, as well as its implementation. Many substances can be detected in blood, urine, or breath, and it may be useful to look for known metabolites of the substances. Relatively few biochemical determinations are as useful as blood-lead levels, however, and often difficulties will be encountered in interpreting results of sampling.

When the above actions have been taken, ideally the industrial hygienist will possess the information required to make an assessment of the hazard potential for the work operations studied. Depending upon the nature of the substances encountered, he may wish to base his actions primarily upon time-weighted average exposures, which may be compared to existing standards, or he may be concerned with short term concentration peaks for other substances. If the data relate to such well known toxic compounds as carbon monoxide or phenol, the appropriate course of action may be relatively easy to select.

In the simplest cases, whenever federal standards of TLVs are available, they may dictate certain courses of action, or at least serve as the best available guidelines. It is much more difficult to take appropriate action when no such standards exist, and unfortunately there are many instances where exposure to toxic compounds does occur, yet no recommended permissible work place limits are available.

Perhaps the worst possible case is the situation where a variety of complex organic compounds is in use, no standards for any of them have been proposed, relatively little is known about the effects of exposure to each, and nothing is known of the possible interactions which may occur either in the atmosphere or within subjects exposed to the mixture. In my own experience, such situations are frequently compounded by yet another variable, that of infrequent or sporadic exposure resulting from batch-type operations.

It is impossible to outline the best industrial hygiene approach to such situations, except in the most general manner. In essence, the industrial hygienist is compelled to act as a TLV committee, or NIOSH standard-producing group, and seek by whatever means possible to make a reasonable estimate of what a permissible air standard should be, as well as what other precautions relating to skin absorption, and so forth, should be taken.

It is highly desirable, if not imperative, that all organizations utilizing a number of compounds for which no official or suggested standards are available, designate a committee consisting of personnel from industrial medicine, hygiene, safety, and other involved units to assemble all available information, and to formulate in-house permissible concentrations for the workplace environment. This committee should further be charged with making recommendations concerning the need for more information, when it is apparent there is almost no data base for making the required decisions.

There is another aspect of modern industrial hygiene procedures which has been growing in importance and will certainly continue to become a subject of increasing concern. As noted previously, there are many instances when data simply do not exist to justify the establishment of a given permissible environmental level of a substance. The 1976 edition of the "Registry of Toxic Effects of Chemical Substances," or the "toxic substances list" as it was previously known, contains some information on nearly 22,000 different substances. Presumably any or all of these may be used by some industries, but OSHA standards exist for less then 500 substances, and many of these are not supported by convincing toxicological or epidemiological studies.

The pressure to obtain better data in order to substantiate a given standard or perhaps to refute a proposed standard has mounted to such an extent that there is a great deal of activity to perform epidemiological studies, usually retrospective, in order that mortality and morbidity findings may be made quickly available. Almost invariably such studies are successful in mobilizing adequate mortality data and possibly even morbidity data but, practically without exception the environmental data will be found wanting. It simply has not been the practice during the preceding decades to routinely sample the work environment in such a way that a large body of data adequate to interpret epidemiological findings is amassed.

It is impossible for the industrial hygienist to create data for the past, of course, but he and the other members of the industrial health team should be examining their own operations for the purpose of determining what sampling data could be useful in establishing the necessary dose-response relationships for substances of importance to the organization. Many examples could be cited, but perhaps the situation with respect to inorganic arsenic is as good an example as possible.

For many years, the permitted exposure to inorganic arsenic was 0.5 mg per cubic meter, until NIOSH recommended in a criteria document issued in 1973 the time-weighted average concentration be lowered to 0.05 mg per cubic meter, or 50 micrograms per cubic meter. Subsequently, evidence released by several industrial arsenic-using companies suggested that some forms of arsenic were carcinogenic, and accordingly, NIOSH revised its recommended standard downward to 2 micrograms per cubic meter in a new criteria document issued in 1975.

Understandably, many industries affected by the new standard were greatly concerned and attempted to mobilize evidence that the proposed standard was far too restrictive. Several major copper smelters were among those most affected by the proposed standard but quickly found themselves in exactly the situation referred to earlier, with inadequate environmental data to support their position. Certain epidemiological studies have shown an increased incidence of cancer in some smelters, and the smelters argue that these cases were the result of greatly elevated exposures in past years.

Although their position may be correct, the smelters are thus far in the position of being unable to present sufficient environmental data to support any apparent threshold of carcinogenic activity. In recent years, however, the tempo of environmental sampling for arsenic has increased greatly, and it is highly probable that it will be possible, in the relatively near future to begin to make reasonable estimates of the apparent threshold of carcinogenicity for arsenic compounds in the workplace.

Unfortunately the long period of time required to produce cancer of occupational origin limits the immediate usefulness of currently acquired data, and this may tend to discourage ambitious sampling programs which could shed substantial light on cancer-exposure relationships. But it is improbable that satisfactory data will be obtained by any other means. Certainly, the industrial hygienist should be encouraged to confer with the epidemiologist regarding his data requirements.

In cases where the toxic compounds are not necessarily suspected of being carcinogenic, studies begun as soon as the industrial hygienist is able to commence them could be valuable in helping to establish no-effect levels and possibly threshold levels. One major chemical company, which has long been noted for the general excellence of its industrial hygiene program, has made it a practice for years to make notations of sensory responses experienced by the industrial hygienist during the course of his sampling and related investigations. The data accumulated over a period of years by several industrial hygienists proved to be very valuable in the formulation of appropriate environmental standards for chlorine, where the principal problem is irritation of the eyes, nose, or throat.

CONTROL

The control of hazards which have been identified and evaluated may be a routine matter which is easily handled by the engineering staff of the organization, or it may be far from routine and entail extremely large expenditures. Certainly, the most common control strategy involves the traditional use of exhaust ventilation, combined with maximum enclosure of the operation. With the advent of ever more stringent standards, however, this approach may not be adequate for many situations, and it is essential that considerations be given to such measures as process alterations which permit the total separation of the worker and the toxic compounds, usually by total enclosure and automation. For some potent carcinogens, this is already a reality, and for many other toxic compounds it is very likely the ~~only~~ practical means of achieving compliance with the near-zero standards.

Control of exposure to toxic compounds by respiratory protection is the "last resort" approach, which should be required only when engineering control is impossible or extremely impractical. OSHA generally frowns upon the use of respirators of any kind, but there are many situations where the use of a well designed supplied-air respirator, for example, may be the best method of accomplishing the required degree of worker protection.

Regardless of the expected consequences of occupational exposure to a substance, it is apparent the requirements of OSHA and the Toxic Substances Act will inevitably increase the demand for good environmental exposure data for almost all toxic compounds in use by industry. Although the industrial hygienist may deplore the burgeoning need for measurements of levels of exposure, it is highly unlikely that the pressure to obtain such information will decline; rather it will tend to increase with the passage of time.

The industrial hygienist and all the other members of the health/safety team should do everything possible to keep up with the pressures created by legislative demands, and if possible, anticipate those demands and have the answers prepared before the questions are asked.

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EMERGENCY MEDICAL PLANNING
AND INDUSTRIAL DISASTER

A Pre-Triage System
for Mass Casualty Care

Max Klinghoffer, MD

For the past eight years, the disaster program at O'Hare Airport has been based upon a two-phase pre-triage program, which is also the pattern for the Memorial Hospital of DuPage County and, in part, for the Chicago Fire Department.

O'Hare Airport has been described as a "city in itself." It occupies 7,000 acres with a post office, many restaurants, a fire department, security police, shops, and a great deal of traffic -- more than I would have believed until I started working there. Last year over 93 million people passed through here; about 40 million were passengers, and the rest were people either meeting the passengers or seeing them off. So with almost half of our country's population going through here every year, you can see why we consider this a high risk area and why it has been felt necessary to have a disaster program contained within the airport. In the case of industry or an aggregate of industries, a similar program can be established.

The problems that arise in an airport disaster are similar to those that could occur in any densely populated industrial area. These involve: the type and location of the accident; difficulty in extrication of victims; traffic congestion; inclement weather conditions; and, above all, <u>immediate</u> life-saving care for the casualties.

Both military and non-military experiences in mass casualty care have demonstrated that the first minutes of emergency care may determine the outcome for the casualties. For this reason, the pre-triage program is aimed at getting basic life-saving services to the casualties in the shortest possible time. The echelons of such pre-triage care are:

1. The emergency care of the casualties at the site of the incident, continuous care during extrication and care enroute to the second echelon.
2. The second echelon includes further pre-triage care and stabilization of the casualties. At O'Hare Airport, this second phase ~~takes place, preferably, at the main fire~~ department.
3. Transportation from the second echelon of care to a neighboring hospital can be considered a third phase.

Obviously, this type of program calls for:

1. Highly mobile equipment for sustaining life and personnel employed within the area who have been trained in the basics of life support.
2. A "back-up" supply of equipment in a preplanned area for further care and stabilization of the patient. This building must be considered for its accessibility and physical characteristics (i.e., temperature, lighting, and area for casualty care). It is preferable that alternate buildings also be designated.
3. Preplanned methods of transportation from echelon two to neighboring hospitals, ALWAYS accompanied by an emergency-trained individual.

Preplanning is also necessary for traffic control within the area involved and from that area to neighboring hospitals. This will necessitate conferences and cooperation with the nearby law enforcement agencies.

The mobile phase of pre-triage at O'Hare is accomplished with 15 pre-triage medical bags, which are stored in a secured area in the main fire station. These bags weigh about 23 pounds and can be hand-carried or slung over the shoulder. A locked vault nearby contains 15 cartons, each with a supply of injectable narcotics -- one carton per bag; keys to the vault are available only to authorized personnel.

Sterilized equipment is sealed to remain aseptic for several years. (We have done serial cultures of some of these packages and have found that the sterility is maintained for at least eight years.) A large plastic sheet (6' x 6') and four spikes are the first items found when the bag is opened. This sheet, held in place by the spikes in snow, mud, or ice, provides a reasonably clean, dry area to place the bag and its contents when in use.

The "back-up" supplies, in the basement of the fire station, are stored on shelves by "row and column" arrangement, and located with the aid of an inventory book which lists the supplies by "row and column" and also by alphabetical cross index. Thus, you will find "Intravenous Fluid" under both "Fluid" and "Intravenous."

Casualties received at the second echelon of pre-triage will be held there until:

1. the patient's condition is stabilized,
2. adequate vehicle (preferably the modern van type) is available for transport to a neighboring hospital,
3. an attendent trained in emergency medical service is present with the driver,
4. availability of a bed(s) at neighboring hospital is known,
5. complete traffic control from the pre-triage site to the recipient hospital is secured.

Obviously, none of the above will function well without adequate communications.

The pre-triage staff consists of regular employees at O'Hare. These include: freight handlers, ticket agents, administrative personnel, mechanics, pilots, postal employees, restaurant employees and so forth. Few of these have had any medical background. However, we have operated this program on the philosophy that a layman trained in the basics of emergency life-saving care and who is at the site when the episode occurs, is of far greater value in the minutes following a disaster than is the most sophisticated physician an hour away.

These trained employees are only part of the pre-triage team. O'Hare Airport fortunately has around-the-clock paramedics who head up the teams until the emergency physicians are available. We are also prepared to call emergency medical personnel who may be in the terminal at the time via the public address system.

Our cadre of pre-triage personnel are trained in the principles of emergency life-saving care, and the establishment and maintenance of the triage equipment at the second echelon. Medical training includes:

1. control of hemorrhage,
2. prevention and treatment of shock,
3. emergency care of burns,
4. immobilization of fractures,
5. cardiopulmonary resuscitation,
6. proper transportation of the casualty,
7. radiation hazards,
8. emergency childbirth
9. and general topics, such as poisoning, diabetic coma, stroke, insulin reaction, venomous bites and stings, and so forth.

Our teaching method involves much demonstration. Not only do we tell what to do, but why it is done. And to maintain interest, we cover many topics that, while remote from the operation of an airport, involve episodes that might occur at home, on vacation, or at the roadside.

Our emergency notification system incorporates 19 electronic "pagers." Dialing a set of digits at any O'Hare Airport telephone simultaneously activates all 19 pagers, which signal all pre-triage personnel to report to CRASH 1 Fire Station. Here, they are quickly divided into two groups: one group carries the 15 bags to the scene of the accident; the remainder move the "back-up" equipment to the firemen's bunk room where they establish Echelon Two. When the first group has completed its duties at the scene of the episode, they report to Echelon Two (the main fire station), where the personnel are assigned to the stabilization of the casualties.

To further expedite emergency care, it is desirable to have a "pre-triage table." We use eight aluminum tables, measuring 3' x 6' when open, with the top of each table separated into five areas: 1. resuscitation equipment; 2. fracture supplies; 3. dressings; 4. intravenous supplies; and 5. records. Accompanying each table is a box containing the equipment for that table.

Temporary morgues should be established near the pre-triage area. Under no conditions, however, should the dead be taken to the area where the living are being treated. It is also advisable to pre-plan for communications with next of kin. In this way, much of the anxiety of relatives, casualties, and the uninjured can be minimized. Such communication centers should be established in advance and should be staffed at the time of a disaster by clergy, Red Cross, or public relations personnel.

The pre-triage system should not be considered a hospital. Rather, it is a "way station" where the patient is stabilized on his way to the hospital. It is the purpose of a pre-triage system to enable the patient to reach a hospital in such condition that he has the optimum chance for survival.

EMERGENCY MEDICAL PLANNING
AND INDUSTRIAL DISASTER

Electrical Injuries

Samuel C. Bonney, MD

The continuing growth of the United States has led to an ever-increasing production of electrical energy. Yet it is interesting to note that despite the steady increase in the use of electrical power, the death rate from electrical shock has remained almost constant. This is graphically illustrated in Table 1.

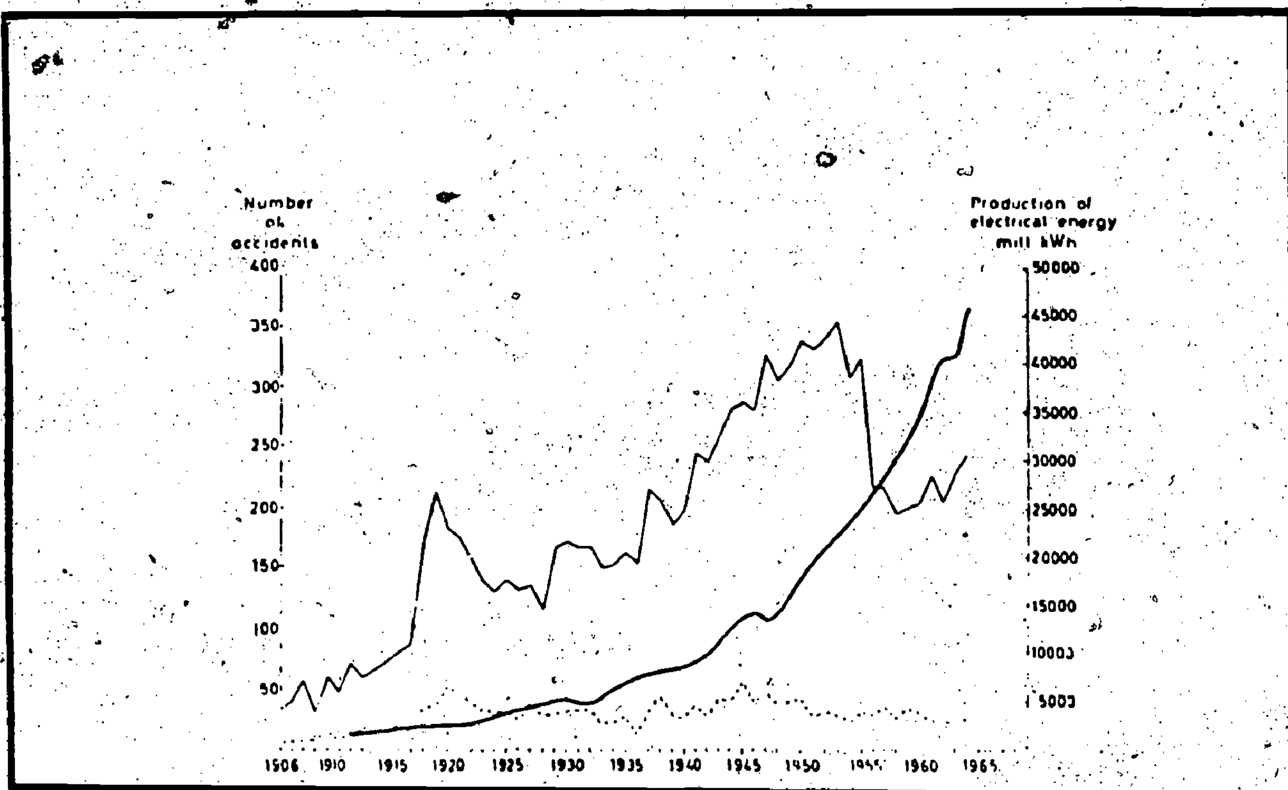
Accidental Deaths Due to Electric Current	1974	1973	1972	1971
Homewiring and appliances	1,157	1,149	1,008	1,065
Industrial wiring and appliances	203	232	206	216
Other electric current	636	564	604	534
Unspecified electric current	155	172	136	160

(Source: National Center for Health Statistics)

Comparable statistics from the works of Skoog (1) in Sweden show a sharp increase in production of electricity that parallels the injury rate, but the death rate remains almost the same. These data speak well for the home appliance industry, which is constantly working to eliminate hazards in its products.

Homes and industries in this country use 60 Hertz alternating current for electrical power. Since this is the type of power most commonly encountered, I shall address my remarks along that direction, disregarding those situations that involve high (radio and TV) frequencies or direct current. This particular frequency is, however, disturbing to the respiratory centers of the brain and the functioning of the heart. Other undesirable characteristics of alternating current include its tendency to cause tetanic contractions, which make it difficult to extricate one's self from contact with the power source.

Table 1
Electrical Injuries



The injuries produced can be divided into two groups: those due to low-tension current and those due to high-tension current. Low-tension current is usually associated with potential differences of less than 1,000 volts; with high-tension current the difference is greater than 1,000 volts (2). In Skoog's series, low-tension current victims were locked to the contacts; in high-tension injuries, on the other hand, the victims were thrown some distance from the contact by the tetanic contractions. High-tension injuries are further complicated by an accompanying electric arc. As a general rule, it can be estimated that a high-tension arc can jump an air gap of one inch for each 20,000 volts of potential difference. Once the arc is established, it can be drawn as far as about 10 feet without collapsing, all the while maintaining a conduction of current between the energy source and the point of lesser potential.

More often than not, an electrical injury is a very complex, destructive force on the human body. Thus, the "true electrical injury" may be combined with an electrothermal burn and/or a flame burn, and also involve associated damage to the cardiorespiratory, urinary or skeletal systems in accompaniment with burn shock. Then too, delayed complications such as hemmorhage, gangrene, bacterial infection, renal failure, paralysis and cataracts may ensue.

The extent of tissue damage, except for delayed complications, is dependent upon the intensity of the current. In its simplest form, (based on a direct current circuit) Ohm's Law describes the relationship between current (I), potential difference (v) and resistance (R):

$$I \text{ (amperes)} = \frac{V \text{ (volts)}}{R \text{ (ohms)}}$$

Thus for a given voltage, the amount of current that passes through the tissue (and which determines the extent of damage) is inversely related to the resistance of the tissue. Putting it another way, for a given resistance, the amount of current flow and concomitant tissue damage will be increased by a corresponding increase in voltage.

The usual entry of an electrical current into the body is through the skin. The resistance of the skin varies with the thickness of the skin and the condition of the skin at site of contact (i.e., whether it is wet or dry). A well-calloused, dry hand, for example, has a resistance of 1 Meghohm (1 million ohms) while a moist hand may have a resistance of only 1,000 ohms. You can, therefore, comprehend the great difference between the effect of 110 volts on the calloused, dry hand as compared with the same voltage on a wet hand.

As the current enters the body, it will travel over the route of least resistance. We find that the electrical resistance of various tissues to the passage of current increases in the following order: nerves, blood vessels, muscle, skin, tendon, fat and bone (2). Thus, conduction proceeds most readily along nerves and blood vessels and least along the bone.

As mentioned earlier, low voltage alternating current causes tetanic contractions which lock the victim to the energy source. The longer the body is in contact with the electrical source, the greater is the damage as a result of heat that is generated within the tissue or body fluid. In the case of high voltage current the duration of exposure may be less, but since the voltage is higher, the current can also be higher, and there can be other injuries produced by violent expulsion of the body from the point of electrical contact.

True Electrical Injury

This is a unique burn injury that occurs when the body becomes the conduit for the electrical current. The extent of injury depends upon the voltage, the amperage, the surface area at the site of contact (or the resistance), the duration of the exposure and the pathway of the current through the body. High-tension injuries, those caused by 1,000 volts or more, are most likely to produce entrance and exit injury sites.

The particular pathway of the current through the body can dictate the type and extent of injury. For example, a 40-60 Hz alternating current of as little as 100 milliamperes that passes through the myocardium can cause a fatal dysrhythmia (2). Morley (4) feels that high-tension currents that pass through the myocardium cause a myocardial contraction, and these are usually fatal--only five cases of successful resuscitation have been reported in these instances.

Postmortem studies of electrical deaths in the United Kingdom showed the heart to be in complete systole. Skoog reported on one patient who had 6,000 volts of short duration enter the right hand and exit from the right leg; the victim was rendered unconscious but had a spontaneous recovery with no residual deficits (1). Unconsciousness can occur when the pathway is not through the central nervous system, and yet may be avoided when the current enters the scalp. Unconsciousness can also result from a tentnizing current across the chest wall that interrupts the muscles of respiration (4).

There were 36 employee fatalities reported to the Edison Electric Institute by the electrical utility industry in 1975. In all of these deaths, the current traversed the myocardium and/or the central nervous system.

Current Pathway	No. of Cases
From Hand to Hand	6
From Hand to Left Foot	11
From Both Hands to Both Feet	5
From Extremity to Chest or Abdomen	4
From One Hand to Both Feet	4
From Head to Legs	3
From Foot to Foot	1
From Both Hands to One Foot	1

For two fatalities, voltage was in excess of 15,000 volts; the rest were at less than 15,000 volts, and the lowest was at 300 volts (2).

Pathology of True Electrical Injury

Tissue damage is due either to the heat produced by the passage of current through the tissue or is a result of a specific action of the electricity on the tissues. The subsequent heating effect (H) may be expressed in terms of voltage (V) and Current (I) as:

$$H_{(\text{watts})} = V_{(\text{volts})}\, I^2_{(\text{amperes})}$$

The area on the skin where the current enters appears dehydrated and depressed with a hyperemic border. The exit area shows considerably more damage with coagulation necrosis. Along the current path through the body the blood vessels show damage, and multiple thrombi are frequent. The peripheral nerves may not show much damage though there is evidence of paresis without anesthesia. (It is fairly typical for the route of conduction to follow the motor fibers in deference to the sensory fibers). There is usually good recovery from any resulting paralysis, unless the vascular supply to the nerves is impaired and cannot maintain the peripheral nerve (2). Muscles usually show extensive coagulation necrosis (2); also, there can be additional harm to the blood supply of the muscle and at sites distal to the muscle by the edema that accompanies the burn (5).

Obviously there can be extensive destruction deep in the tissues after a "true electrical injury". This deep injury is not apparent on the first examination after the incident. Skin burns are apparent, but this burn is unusual in that it is more like a crush injury.

Electrothermal Burns

This type of injury is caused by the heat generated when there is arcing, which is usually associated with high-tension current. The arc is created when body contact is made with a charged conductor. The temperature of the arc can range from 1,000°C to 4,000°C, which is sufficient to melt the body tissues (1). The injury produced is dependent on the voltage of the conductor, the part of the body in contact with the arc, and how and where the body is grounded. The higher the voltage, the higher the temperature of the arc and the greater its ability to leap through space (3). After the arc strikes the body, the current travels through the body producing a "true electrical injury" as well. Pathology of pure electrothermal burns shows severe coagulation necrosis and carbonization of tissue.

Flame Burns

Heat produced by an arc can be great enough to ignite clothing or other flammable articles at the injury site. The flame burn from electricity is the typical 1°, 2°, or 3° burn. If the clothing is burned, there are frequently 3° burns.

It is not unusual for an individual with electrical burns to exhibit the flame burn, the electrothermal burn and the "true electrical injury". However, flame burns may be so severe that one may fail to recognize the occult areas that are due to the "true electrical injury".

Contact with a high-tension wire while erecting a radio antenna is a common type of electrical accident. In one such case, there was injury to both arms, the chest, abdomen, scalp, and right buttock and both feet. Despite the extent of his injuries, especially to the scalp, the patient did not lose consciousness. He was in shock and his urine showed hemoglobinuria; fasciotomies were required emergency treatment, as well as extensive debridement. After 48 hours, the patient's right arm was amputated at the shoulder, and he lost some of the digits of the left hand and a full thickness of skin of the abdominal and chest walls. Later, the full thickness of his parietal bone was debrided to expose an intact dura. Nevertheless, he recovered with no central nervous system dysfunction.

This case illustrates the severity of an electrical injury. Far more care and treatment is required than for the usual severe burn patient who has enough skin remaining to survive. Skin losses were full thickness tissue down to and including the underlying bone. The exact depth of the injury can rarely be ascertained immediately after the accident, and frequently 42-72 hours is necessary before the depth of the tissue necrosis is apparent. Severe electrical injuries frequently involve functional parts of the body i.e., the hands and/or the feet.

Associated Injuries

When "true electrical injuries" occur, there may be unconsciousness and respiratory arrest even though the current does not pass directly through the respiratory centers and the brain stem. In DiVincenti's series, 29 out of 65 patients had CNS complications, but only six had entrance wounds over the scalp. Transmyocardial currents may produce dysrhythmia and cardiac arrest; 8 out of 65 showed ECG changes (2). A United Kingdom study of 7,724 electrical accidents showed 496 of the victims were rendered unconscious. Careful evaluation of the accident reports revealed that two out of three had only respiratory arrest, while one out of three had an absent pulse and cardiac arrest.

Severe damage to body tissue by electrical injury causes the release of myoglobin into the circulation and genitourinary system from damaged muscles. The injury also causes a loss of body fluids into the damaged area. This combination of body fluid loss and high concentration of abnormal protein from the muscle creates a renal complication similar to that seen with crush injuries (3). Hemochromogens may appear in the urine. However, the vast majority of the pigment can be identified as myoglobin (6). The longer the pigment persists in the urine, the greater the amount of muscle damage.

The severe tetanic contractions characteristic of alternating current can also cause fractures and dislocations of the skeletal system. These fractures may occur as a direct result of the violent muscle contractions or indirectly from the falls that are frequent from high-tension lines. In DiVincenti's group 7 out of 65 had fractures (2).

Severe electrical injuries also produce shock similar to that seen with other burns. The shock is due to the leakage of plasma from the circulation through the heat-damaged capillaries. In addition, there may be an increase in the permeability of the endothelium of capillaries distant from the injury as the result of toxins released from the injured tissues. Fluid loss begins immediately after the injury and progresses rapidly during the next 8-10 hours. This loss is usually stabilized within 48-72 hours. There may be a continued fluid loss in the areas where there is a skin loss, which will persist as long as the wound remains unhealed. The exudate is primarily plasma and protein substance; red cell depletion is usually less than 10%.

Hemmorhage is common after an electrical injury. The blood vessels are injured by the current passing along them; the larger blood vessels may bleed profusely from the damage. The thrombi that are formed and the damage to the vessels may produce stasis at first. Later, the thrombi may disappear, followed by very severe hemmorhage.

The initial injury to the blood vessels and tissues may be sufficient to compromise the circulation of the digits and extremities and result in gangrene. The thrombi cause ischemia and the vascular supply to the extremities is further impaired by the leaking of fluid into the injured tissue. Fasciotomies are needed early to lessen the loss.

The injured and devitalized tissue readily becomes an excellent medium for the growth of bacteria leading to severe infection. Clostridia is a common organism. The devitalized tissue must be removed and rarely is it accomplished in one debridement.

There are heavy demands on the kidney from the moment of injury. The "burn shock" decreases the circulating volume and the excretory load is increased by the by-products of injured muscle. This combination can cause a shutdown of kidney function and require renal dialysis.

The resultant paralysis may be temporary or even permanent if the blood supply and nerves are sufficiently damaged. Physio-therapy can be utilized once the general condition of the patient improves.

The occurence of cataracts is a late complication and may occur months after the original injury. Origin of this disorder can be traced to the thermal radiation from the high temperature arc.

Emergency Care

The injured person must be removed from the energy source prior to initial care. Special equipment and personnel may be necessary in order to extricate the victim and to avoid additional injuries to the victim or his rescuers.

The ABC's of Cardiopulmonary Resuscitation (CPR) must be the first consideration. Check the airway and breathing. Referring again to Morley, he found that 2/3 of the individuals who were apneic after the accident were found to have effective heartbeat and needed only respiratory resuscitation. Morley also analyzed the various methods of respiratory resuscitation. Inasmuch as the apnea may be due in part to the severe tetanic contractions of the muscles of respiration, it is reasonable to believe that the simple movement of the victim can be an important factor in breaking up the muscle spasms. Absence of heartbeat will suggest the presence of ventricular fibrilation; thus, external cardiac compression should be started immediately. The cardiopulmonary resuscitation should be continued until the person is transferred to an advanced life-support system.

Method	% Recovery
Schafers or Holger Nielson (Manual Method)	50
Mouth-To-Mouth (13-64)	20
Positive Pressure Breathing Machine (10-44)	22
Untrained Witnesses (Just moved arms and legs of victims (7-7)	100

Don't use the "rule of nines" to calculate the fluid needs of electrical injury patients. This type of injury is very deceptive at the onset and must be treated as if it were a crush injury. The fluid loss must be anticipated and its replacement must be sufficient to accommodate the "burn shock" fluid loss in addition to a urine output of 30-40 ml/hr. Hence, catheterization is essential in combination with the intravenous fluids. Monitoring of the urine flow is mandatory to prevent renal damage.

General Assessment of the Patient

After the life-threatening traumas have been assessed and treated, a more thorough examination of the victim should take place to detect damage other than that arising directly from the burn. Take an ECG to look for myocardial involvement along with baseline laboratory studies on the blood gases, electrolytes, hemoglobin, blood type and crossmatch. The presence of acidosis should be anticipated and treated accordingly.

Estimate and record the percentage of body surface area affected. You may cover the thermal burns of the skin with a clean, dry dressing; sterile sheets are adequate:

The superimposed "true electrical injury" may be masked by the thermal injury to the skin; therefore, look for entrance and exit wounds which will indicate that the current has passed through the body. The entrance wound is typically a depressed area while the exit is marked by an expulsive appearance--as if the skin were actually thrown out. Paralysis of an extremity with preservation of the sensory system in that extremity is indicative of a "true electrical injury". Persons who fall after an electrical shock may have injuries of the chest, abdomen or even the kidneys. These injuries should be treated by appropriate emergency procedures. Likewise, skeletal injuries should be identified, splinted and stablized. As soon as the victim's condition has been stabilized, he should be transferred to a burn care center.

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EMERGENCY MEDICAL PLANNING
AND INDUSTRIAL DISASTER

Initial Management of the Burned Patient

William W. Monafo, MD

More than two million persons are burned annually in the United States. Until better preventive measures are instituted, the care of the burned patient, both immediate and late, will continue to be a health problem of serious proportions.

Proper immediate care necessitates an appreciation of the many potential problems--apart from the obvious burns--that may confront these patients. Prompt and comprehensive treatment of the extensively burned patient by the initial emergency team is required, not only for successful resuscitation in the receiving hospital or burn center, but also for avoidance of serious complications and late fatalities in those who survive the early shock phase. The role played by those who are responsible for the burned patient's initial care cannot be overestimated.

IMPORTANCE OF MEDICAL HISTORY

Incomplete or inaccurate information about the injury or past medical history, inaccurate assessment of the depth and extent of burns, and failure to recognize associated, potential serious, non-thermal injuries are common errors in the initial assessment. These often result in an excessive or inadequate rate of intravenous fluid therapy or omission of a required treatment that is essential for survival.

An accurate and detailed history of the thermal injury is needed to predict depth of the burns and likelihood of other associated injuries. In descending order of burn depth are pure electrical burns, flame burns with ignition of clothes, flash burns, immersion and scald injuries. Associated injuries often exist, especially when the burns result from an explosion or a highway accident. Pelvic fractures with concealed retroperitoneal hemorrhage, subdural hematoma, and pneumothorax may coexist with extensive cutaneous burns; if ignored, they can result in unexpected early or late fatality. Respiratory insufficiency with hypoxemia and circulatory collapse with lactic acidosis due to rapidly developing hypovolemia are common, immediate threats to survival.

Severe inhalation injury due to exposure of the respiratory epithelium to toxic gases is normally seen when the victim was exposed to flames and smoke in a closed space; however, mild inhalation injuries can occur in open spaces as well.

Burns around the nares and mouth, singed nasal hair, carbon in the oropharynx or carbonaceous expectoration, hoarseness, cough, cyanosis, rales or wheezes, and mild to moderate hypoxemia are all important findings in inhalation injury. The noxious gases of combustion can cause severe hypoxia and immediate death as a result of carbon monoxide poisoning or can chemically injure the larynx and trachea and/or the pulmonary parenchyma. Usually, radiographs of the chest are initially normal. Perfusion-ventilation xenon lung scans show the expected defects. Early fiberoptic bronchoscopy is the most reliable means to establish the diagnosis of inhalation injury, but it is best deferred until the patient reaches the definitive care facility.

Electrical injuries deserve special attention because potentially they may cause serious sepsis and loss of limb as a result of injury to the muscles and vasculature, death due to cardiac arrhythmia, or apnea from injury to the respiratory center in the brain stem. Unfortunately, these serious or fatal complications can occur in patients who may have small or negligible cutaneous burns and thus be considered trivial.

MANAGEMENT OF THE RESPIRATORY SYSTEM

Significant respiratory insufficiency is not an expected finding within a few hours after burn injury. On the contrary, most patients initially develop respiratory alkalosis as they hyperventilate due to the acute emotional disturbance and pain. However, fatalities can occur as a result of severe hypoxia due to carbon monoxide poisoning, upper airway obstruction, and laryngeal edema in inhalation injury.

Associated thoracic trauma, e.g., pneumothorax and preexisting chronic obstructive pulmonary disease are serious causes of early respiratory insufficiency. Appropriate therapy is necessary prior to transfer.

The burned patient is potentially at risk at all levels of the respiratory apparatus. Recognition of existing problems and prevention of potential ones is vital for survival.

Respiratory center depression can occur from overzealous narcotic or barbiturate administration or overdose in suicidal cases. A drug screening blood sample should be obtained in such instances. Barbiturates should be avoided as they can cause severe agitation. Narcotics should be given only intravenously and in small doses to titrate accurately the minimum doses required for analgesia and sedation.

Transnasal oxygen enrichment of the inspired air is needed for all patients with greater than 30% BSA burns. Oxygen should be given to elderly patients even if the wounds are minor. Oxygen at a flow rate of four liters per minute is all that is needed for most burned patients prior to and during transfer.

Dyspnea and tachypnea may result from subdermal circumferential, constricting burns of the thorax or abdomen which seriously impede and diminish inspiratory expansion of the thorax or diaphragm. Cruciate escharotomies from lower neck to the xiphoid process and circumferentially in transverse direction along the thorax usually relieve the dyspnea and tachypnea by increasing the tidal volume and reducing the respiratory work load.

Upper airway obstruction due to massive edema, especially when the larynx is involved, may necessitate immediate endotracheal intubation. The nasotracheal route is preferred. Immediate tracheostomy is usually unnecessary and may result in subsequent increased morbidity and pulmonary infection, especially if the tracheostomy is performed through burned skin.

Varying degrees of ileus may regularly accompany thermal injury. Nasogastric tube decompression and emptying of the stomach prevent further ventilatory insufficiency, due to elevation of the diaphragm, and also protect the patient from a potentially fatal aspiration pneumonia.

Endotracheal intubation and thoracic escharotomy to improve ventilation will rarely be needed and should be considered only for extensive injuries and especially when transportation time is greater than one to two hours.

MANAGEMENT OF THE CIRCULATORY SYSTEM

It is mandatory to promptly infuse an effective saline solution intravenously at an adequate rate, as the magnitude and rate of plasma loss is great (proportional to the burn extent) and poses an immediate threat to survival.

Venous cannulation should be performed preferably through unburned skin by venous cutdown only; percutaneous venous short catheters or needles are usually plagued by an interruption of flow during moments of agitation and as the edema increases.

Thermal injury depletes all of the blood constituents; however, rate and magnitude of loss of each blood component is different. Red cells are initially destroyed by the transmitted heat and, subsequently, as a result of hemolysis due to spherocytotic transformation of the injured erythrocytes. Within the first 24 hours, the circulating red cell mass may be reduced by one-third in patients with 50% or larger BSA flame burns. Fifty percent of the intravascular protein mass can be lost from the circulation during the first five hours or so. Salt and water losses are by far the most rapid and significant in magnitude. Plasma volume can be reduced by one-half in the first two hours postburn or by one-fifth after five hours despite mild to moderate red cell mass destruction; proportionately, much more plasma sodium and water is lost. The net effect is hemoconcentration that usually returns toward normal, even with aggressive fluid therapy, only after 48 hours or more.

Blood need not and should not be administered initially to most burn patients, as it can cause further increase in blood viscosity and impede capillary circulation. But it may be necessary if there has been significant hemorrhage from associated injuries.

The pathophysiologic effects of a major burn are blood volume reduction, increased blood viscosity, decreased cardiac output, decreased glomerular filtration rate and consequent oliguria.

The basic cause for the hypovolemia is a heat-induced capillary hyperpermeability, which results in massive extravasation of water, salts, proteins, and even erythrocytes into the wound. This abnormal hyperpermeability of the capillaries usually persists for 36-48 hours. Some physicians still recommend the administration of large quantities (from 0.5 to 1.0 ml/kg/% BSA burn) of plasma or albumin in an attempt to restore plasma volume by increasing the plasma oncotic pressure. We disagree! It is clear that plasma administration in the treatment of postburn hypovolemia is expensive and unnecessary. The worldwide trend is away from the use of colloid. On theoretical grounds, the exogenous plasma proteins can be expected to share the same fate as endogenous proteins: to accumulate in the wound where they increase tissue oncotic pressure and thus tend to exaggerate and prolong edema. More importantly, no one has proved that the use of colloid increases either quality or rate of survival.

Salt water therapy on the other hand, replenishes the predominant losses, is readily available, and is inexpensive. Sodium, the principal osmotically active cation of the extracellular space, plays the major role of maintaining and restoring extracellular space and plasma volume. Most experts now use sodium solutions exclusively during the initial treatment of major burns. Ringer's lactate (a hypotonic sodium solution-130 mEq sodium/liter) is usually administered at 4 cc/kg/% burn in the first 24 hours, but its use often causes unnecessarily massive edema of both burned and unburned parts. We have successfully used a hypertonic lactated saline solution (sodium 250 mEq/liter, lactate 100 mEq/liter, chloride 150 mEq/liter) with smaller gains in body weight and less edema. The solution is infused at a rate to ensure an hourly urine output of about 30-40 cc. This hypertonic saline, containing almost twice as much sodium as Ringer's lactate, has proved to be equally as effective; usually half as much fluid is used as compared to Ringer's. Such therapy thus minimizes the risks of cardiopulmonary overload and pulmonary edema, and also prevents excessive wound edema and its deleterious consequences of delayed healing. The exogenous lactate anion acts as a bicarbonate precursor and generally maintains a normal pH by neutralizing the dilutional acidosis trend of the excess chloride (150 mEq chloride/liter vs serum chloride of 100 mEq/liter). Plain Ringer's lactate is available in all emergency units and should be the first intravenous fluid for patients with burns exceeding 15% BSA. It should be administered at a rate that maintains a urine flow of 30 cc/hr in adults. Glucose should not be initially administered, as stress hyperglycemia is usually present; exogenous glucose may further increase the serum osmolarity and precipitate hyperosmolar non-ketotic coma. Patients with delayed or inadequate initial intravenous fluid therapy often require larger fluid loads or fail to respond to treatment.

MANAGEMENT OF THE WOUND

The first principle in wound management should be to avoid further damage or contamination. Cold water towels, if applied immediately after the burns, not only soothe the pain but may also diminish the penetration of thermal injury. Dry, clean, bulky bandages or sheets should be applied next to prevent contamination. Immersion in non-sterile water can seriously contaminate the eschars and produce wound sepsis. Washing or scrubbing with soap or "antiseptic" solutions should be avoided in order to prevent further chemical or mechanical trauma. Gross and obvious debris should be removed gently, and the extent and depth of the burns determined. In circumferential subdermal burns, if the eschars are tight, leathery, and potentially constrictive, one should check status of the circulation distally; note carefully the speed of capillary filling, presence or absence of distal pulses, and whether sensory or motor nerve deficit exists. Doppler ultrasound may be used to detect weak pulses and to read inaudible blood pressures.

Circumferential burns of the leg can cause foot drop due to compression of the neurovascular bundle by increasing edema in the anterior compartment; loss of digits or the hand may follow burns of the upper limb. Such complications can be prevented by generous escharotomy performed prior to transfer; one should achieve about two finger breadth separation of the cut eschar edges, carrying the escharotomy all the way to the muscle fascia to ensure adequate release. One common error of escharotomy or fasciotomy is not extending the incision far enough proximally and distally.

In electrical injuries, compression is caused mainly by the deep fascia surrounding the compartment musculature; therefore, fasciotomy is often required in addition to escharotomy to achieve adequate decompression of the electrically injured and edematous muscles.

WHEN TO HOSPITALIZE

Hospitalization is generally recommended for 2° burns of greater than 10%-15% BSA. Smaller 2° burns in the elderly and in children less than five years old are preferably hospitalized because of increased morbidity in these age groups. Smaller wounds of the face, perineum, hands, and feet are also best managed on an in-patient basis. All electrical and inhalation injuries should be hospitalized because of potentially serious complications. Third degree burns, even of small extent, should be hospitalized. Prompt excision and grafting allow healing in the shortest possible time and minimize the morbidities of prolonged burn wound care, e.g., sepsis, pulmonary embolism.

WHEN TO TRANSFER TO A BURN CENTER

In general, patients with greater than 30% BSA burns should be transferred to a burn center. True electrical injuries that often threaten the viability of limbs and result in serious sepsis and organ failure are best managed in burn centers. Patients with significant inhalation injury also require intensive care and should be treated in a burn center.

Finally, physician-to-physician consultation is strongly recommended to ensure proper initial care and correct and safe transfer of the burned patient.

EMERGENCY MEDICAL PLANNING AND INDUSTRIAL DISASTER

Disaster Planning at a Large Corporate Headquarters

Ann R. Ducey, RN

Monsanto was founded in 1901 by John F. Queeny, in a warehouse on the St. Louis riverfront. Its first product was the now-controversial saccharin, on which production was stopped in 1969. In 76 years, Monsanto has grown into the fourth largest chemical producer in this country. More than 5,000 employees work in more than 20 buildings on the 291 acres that make up our world headquarters campus here in St. Louis.

To protect our people from natural disasters and accidents, we in the Medical Department, along with our friends in the safety and security departments, have developed emergency procedures and facilities for dealing with industrial disasters.

Planning for an industrial disaster is like buying a snow shovel and long woolen underwear. We hope we'll never need them, but we don't want to be caught with our pants down and up to our navels in snow. It's hard to plan disasters and accidents so they happen when we're ready for them. Since we're used to a semi-orderly world, where roofs stay on buildings, electric lights work, and we have food and water, it's not a pleasant thought to plan on losing these things. But that's exactly what we're doing when we draw a blueprint for an industrial disaster plan. We're preparing to lose things we depend on every day of our lives-- and then to cope with the situation after the loss occurs.

Defining the probable emergencies depends a great deal on geographic location and type of work. Ultimately, no area and no type of business are immune to any kind of disaster. However, we have found that disasters are most often caused by factors outside the control of the individual business establishment. The South and East Coasts are hurricane-prone; the Far West has a major earthquake belt; we in the Central States live in "tornado alley."

The particular emergencies we provide for include: tornadoes, power blackouts, utility failures, fires or explosions, civil disturbances, bomb threats, and military attacks. Of course, we must be ready to deal with the wide variety of medical emergencies which can happen any time in a population as large as we have-- from sprained ankles to coronaries.

We have prepared an emergency procedure manual, detailing the actions to take for each of these emergency situations. And although we realize that nothing is ever going to happen exactly as it's written in the book, this manual is extremely important.

We have three full-time doctors and two full-time nurses, who are ready for anything. The facilities rival those of a hospital emergency room: we are fully equipped with examining rooms, x-ray equipment, wheel chairs, stretchers, cardiopulmonary resuscitation equipment-- the works. It's possible for us to x-ray and examine seriously injured persons on-the-spot and give them emergency treatment. We can use our fully-equipped ambulance to send severe cases to area hospitals.

Each of the medical staff is trained in CPR, oxygen, and the use of all emergency equipment. Our emergency rooms, ambulance, and site security and safety office are all connected by telephone hotlines and two-way radios. We also have a direct phone line to area hospitals. During any disaster, the site security and safety departments act as the central control point. A control board monitors fire, burglary, and smoke alarms in all facilities across the campus. Medical facilities and the security control center have an emergency power supply for the electric lights in each building.

During any disaster, we get additional help from "monitors" (people chosen by the Personnel Department and trained by Safety and Medical) who act as leaders in getting people to safety. They have responsibility for the physical security of a specific group of people near their working area.

Unlike our various plant sites across the country, we handle only small quantities of chemicals at this headquarters site, but we experiment with an extraordinary variety of chemicals and chemical processes. There are over a thousand people in seven multi-story laboratory buildings. Professionally trained, they have a lot of knowledge and respect for the materials they work with. Most experiments are conducted in ventilated hoods or in work areas where hazards are kept at a minimum. But accidents are an unfortunate fact of life!

Our emergency procedures for chemical explosions or fires in laboratories are different than they might be at the manufacturing locations. For example, 95% of our burns can be successfully treated with an ice-water soak. When more serious accidents happen, proper training of all the people in the labs is critically important. Recently, a female technician's clothing caught fire. In seconds, the flames had reached to her hair. Because one of her co-workers had been properly trained, he knew which fire extinguisher to use and how to use it properly. His quick action not only saved her life, but also limited her injuries to second-degree burns.

Regular training sessions are held for everyone in the laboratories--including managers and secretaries--in the use of air packs, fire extinguishers, and other emergency equipment. Special fire brigade teams get extra training to handle major emergencies. Every wing of every floor in the research center buildings has an electronic board which identifies the location of an emergency and sounds an alarm. Fire-fighting and life-saving equipment is also located near these boards. Equipment to handle other emergencies, such as acid spills, is also available at many locations throughout the labs. Special safety equipment is provided at arm's reach for those working where there is a possibility of an unusual accident. Showers and eye-washes are located every few yards in all laboratory hallways.

Natural disasters pose the greatest overall threat to human life and property. The weather can be particularly dangerous for us in the Midwest. Tornadoes are very prevalent in the St. Louis area from March through September, thus our emergency manual lists the physical description of tornado weather up front with emergency telephone numbers.

When threatening weather is recognized, the storm's movement is plotted on maps by the security people. Whenever a tornado is sighted within 30 miles of our location, the security and safety crews alert all employees by public address. Interior stairwell doors are opened and elevators are lowered to the ground floor. Outside doors are propped open to equalize pressure. Ambulance drivers park in underground garages, power plant personnel perpare to shut down machinery, and the monitors are notified.

As the tornado closes to within 20 miles, a "take-cover" message is broadcast at least three times over the public address system. Everyone is evacuated to a pre-assigned place in the underground tunnels which connect all of our buildings. The Medical Department establishes a first-aid station on each side of the campus in a central area, and the power plant is shut down. After the "all-clear" announcement, damages are assessed and employees are either evacuated from the grounds or they are free to return to work.

I know all will agree that the primary purpose of planning for an industrial disaster is to save lives or prevent injury. And, if possible, we want to minimize the damage to property. Both can be done effectively by preparing in advance.

First, identify and define the emergencies most likely to strike. Then design the procedures most likely to deal effectively with these emergencies, and prepare written instructions in an emergency manual. Medical and safety departments should work together to implement these procedures. Finally, make available the necessary equipment for dealing with emergencies, and train your people to use this equipment.

Doesn't all of this preparation cost a lot of money? Sure it does. At our World Headquarters we spend hundreds of thousands of dollars just to be prepared for an event or an accident we hope will never happen. But if the unthinkable does happen, then no amount of money is too great if it saves a life or prevents a disabling injury. There are some things that simply cannot be measured in dollar signs.

There also is no such thing as a convenient disaster. A disaster is something you can't anticipate with certainty, like taxes, Christmas, or wrinkles. Disasters are uncanny creatures that seem to be governed by Murphy's First Law: If something can go wrong, it will at the worst possible moment.

I know it sounds simple, but the only way to really safeguard human lives and property against disasters and accidents is to be prepared!

INDUSTRIAL TOXINS AND THE COMMUNITY

Introductory Comments

Clark W. Heath, Jr., MD

It may seem odd for a meeting concerned with worker health to include a session on community health. Worker and community health, however, form a single spectrum which it is well to consider as a whole, particularly in relation to toxin exposures of industrial origin. Conceptually, the two areas are distinguished mostly by potential differences in dose and in mode of toxic exposure. Potential health effects as well as sources of exposure remain much the same, with industrial control measures often having the effect of protecting both groups at the same time.

Dealing with community exposure problems, however, may be a more difficult, complex, and frustrating task than dealing with comparable worker exposures. Again, it is dose and mode of exposure that underlie these difficulties, rather than fundamental differences in pathologic mechanisms or methodologic approach. Let me briefly illustrate how such problems affect community studies using as an example the recent Kepone exposure episode in Hopewell, Virginia. The four presentations that follow will expand on many of these same points.

The Kepone contamination incident involved a small chemical plant which exclusively produced the chlorinated hydrocarbon insecticide, Kepone, over a 17-month period (March 1974 through July 1975). Very few production safeguards were employed in the plant's operation, resulting in extensive worker exposure to the chemical, as well as unchecked environmental contamination outside the plant. Health effects in workers have included neurologic abnormalities and sterility. When the incident came to public health attention in July 1974, simultaneous studies of worker and community health effects were undertaken.

DOSE OF EXPOSURE

Studies involved various groups of people exposed in different ways outside the plant, as well as current and former plant workers. In the vicinity of the plant, varying degrees of environmental contaminations were demonstrated, largely the result of airborne Kepone-laden dust from the plant. Main attention focused on a general population survey of persons living within a mile radius of the plant. Survey workers measured serum Kepone levels and asked questions about potential health effects, primarily neurologic. Also studied were workers formerly engaged in Kepone production at a nearby Allied Chemical Company facility, persons employed in unrelated businesses located close to the contaminated plant, workers at the local sewage treatment facility where the plant discharged Kepone waste, and members of the families of workers at the plant.

Neurologic illness attributable to Kepone was found only in current or former workers at the chemical plant (76 of 133 persons, 57%) with no such cases being found in any other group. Kepone, however, was detectable in all groups, although in distinctly higher levels in chemical workers, especially in workers with presumably Kepone-related illnesses.

Table 1. Blood Kepone levels in different exposed population groups, Hopewell, Va.

	No. tested	No. positive (%)	Range*	Mean*
Chemical plant workers				
Ill	57	57 (100)	0.009-11.8	2.53
Not ill	49	48 (99)	0.003- 4.1	0.60
Families of workers	32	30 (94)	0.003- 0.39	0.10
Allied chemical workers	39	30 (77)	0.003- 0.45	0.06
Neighborhood workers	39	25 (64)	0.003- 0.031	0.010
Sewage workers	10	6 (60)	0.004- 0.014	0.008
Hopewell residents	214	40 (19)	0.005- 0.033	0.011

*Parts per million

While these findings suggest that only relatively high levels of Kepone cause illness, the negative clinical findings in groups outside the contaminated plant are only superficially reassuring, given the crude clinical measures available and concern that Kepone exposure may involve delayed health effects, such as cancer, where dose relationships are as yet undetermined. As in other community health studies, negative results do not provide a final answer, although they may represent the best that the art allows. In the meantime, toxin absorption outside the workplace has been documented.

MODE OF EXPOSURE

In addition to dust pollution in the vicinity of the plant, Kepone was also discharged in large amounts into the city sewage system, finding its way ultimately into the James River, where it has been taken up by the aquatic food chain. Given the relative non-degradability of the compound, the situation poses a persistent problem in environmental contamination that has no easy solution. It means that in contrast to workers whose exposure was mostly from the single source of Kepone production, community exposure has involved not only contact with airborne Kepone dust, but also ingestion of Kepone in seafood. It also emphasizes that the community problem is more diffuse and hence more difficult to assess and control than the worker problem, where exposure was concentrated at one discrete location.

Because of these difficulties, and because the one community health survey involving persons near the plant produced negative results, no broader study of potential community health effects has been undertaken. Instead, public health efforts have focused on continued environmental monitoring and control of contaminated seafood sources.

In this manner, problems posed by dose and mode of exposure have made the community health problem in relation to Kepone difficult to assess and manage satisfactorily. In all such situations, of course, difficulties in public health management are often magnified and at times distorted by the public attention they arouse, as well as by economic and political repercussions. While similar reactions accompany worker health problems, such forces can be particularly prominent in the less easily defined setting of potential community health effects. Problems of this sort will be discussed by several of the speakers to follow, each representing a rather different viewpoint on this complex public health subject.

INDUSTRIAL TOXINS AND THE COMMUNITY

Arsenic Contamination Near a Copper Smelter

Samuel Milham, Jr., MD

The first, and most convincing, evidence that environmental esposures could cause chronic diseases and cancers came from the occupational setting. The larger and more recent question is whether community exposures to the various man-made pollutants in air causes disease. The National Research Council (1) and other groups have addressed this problem in general. In this paper, I would like to share the experiences I have had in the past five years studying the community around a large copper smelter in Tacoma, Washington.

Since 1889, the American Smelting and Refining Company has operated a smelter in Ruston, Washington, an administrative enclave north of, and contiguous with, the city of Tacoma. The smelter is located on a peninsula which extends into Puget Sound (Figure 1). Although built originally as a lead smelter, since 1913 the facility has been a copper smelter specializing in processing copper ores high in arsenic; and it is a major producer of arsenic trioxide (AS_2O_3).

There are homes within 50 yards of the smelter stack, and there is a public elementary school (Ruston School) within 300 yards of the smelter complex. Current estimates place smelter arsenic emissions at about 1,000 pounds per day.

Two facts have emerged in the past five years, which place a special burden on those responsible for community health in Ruston:

1. Ruston residents have increased exposure to arsenic trioxide.
2. Inhaled arsenic trioxide is a respiratory carcinogen.

Children living near the smelter have been shown to have increased levels of arsenic in hair and urine (2). Urinary arsenic levels decrease with distance of residence from the smelter. Evidence that exposure to arsenic may be by inhalation comes from three different pieces of information:

1. Community air contains elevated levels of arsenic, especially when the smelter is operating.
2. Urinary arsenic levels were reduced in the community during a period of smelter inactivity related to a strike (Table 1).
3. Urine arsenic levels in children varied synchronously in samples obtained once a week over a five-week period (2).

The evidence that inhaled arsenic trioxide is a carcinogen is summarized in a NIOSH criteria document (3). Workers at copper smelters, including the Tacoma smelter, have been shown to have increased mortality from lung cancer (4,5). Workers at pesticide formulating plants with arsenic trioxide exposure have also been shown to have a similar lung cancer incidence increase (6,7).

Studies done at the Tacoma smelter have shown that smelter air arsenic levels are positively correlated with urinary arsenic levels in workers (8), and that measures of arsenic exposure in workers (urinary arsenic) are directly related to lung cancer incidence.

Given the above relationships, it is natural to consider whether there might be a lung cancer risk in the community around the smelter due to inhalation of arsenic. An assessment of lung cancer rates by census tract in Tacoma was unrevealing. Excess lung cancer rates in areas around the smelter disappeared when smelter workers were removed from the counts.

Initial urinary arsenic sempling in the community began in June, 1972. Over the past five years, numerous samplings have been done in Ruston, adjacent Tacoma, and Fern Hill Elementary School, a school about 12 miles from the smelter used as a control. Table 2 shows sampling results from the study period. For comparison, normal urinary arsenic levels are 0.014 ppm (14 micrograms/liter). No obvious trends are visible in the data. For comparable groups, arsenic levels are about the same now as they were when sampling began. The smelter has undertaken extensive emission control measures over this time period, which resulted in a halving of arsenic emissions over the study period. No similar trend is discernible in the urinary arsenic sampling.

Table 3 shows daily urinary arsenic sampling for nine consecutive days for a group of children collected in family groups. It is my feeling that long-term sampling in the same individual is more revealing of community pollution patterns than 1-day sampling of large numbers of children. Over the sampling period, marked day-to-day variation in urinary arsenic level is seen in the same individual. The highest levels of urinary arsenic seen in the study are well into the range of urinary arsenic values seen in smelter workers.

Urinary arsenic levels on a given day will be affected by many variables: smelter emission rates, wind direction and velocity, place and motion in the community, respiratory rate, and ingestion of arsenic. Early in the sampling it became evident that seafood ingestion could cause increase in urinary arsenic. To make our results comparable with others, we also found it necessary to resort to urine specific gravity adjustments. Since published normal or control values for arsenic are based on data nearly 30 years old (9), I think it is important that more recent normal level information be developed.

Studies of morbidity in Ruston students in terms of growth (10), school attendance, hearing, and hematologic values (11) were unrevealing.

To make rational judgment about whether the current ambient air levels of arsenic in the community are hazardous in terms of causing lung cancer, more information is needed. To obtain this information, two mortality studies are currently in progress. With the cooperation of smelter officials, we have obtained urinary arsenic data for workers going back as far as the 1940's. This exposure information will be correlated with a concurrent mortality study in smelter workers to examine the relationship between arsenic exposure and mortality from respiratory cancer. We hope this information will allow us to examine the "threshold" question: Is there a level of ambient air arsenic below which no lung cancer is seen? The Occupational Safety and Health Administration has proposed an 8-hour workroom ambient air standard for arsenic of 4 micrograms per cubic meter of air. This level is, on occasion, exceeded in the community air a mile from the smelter for three or more consecutive 8-hour periods (9). The study should also provide a rational basis for setting the workplace arsenic standard.

The second mortality study in progress is an attempt to see whether exposure to community air in the past caused any unusual mortality patterns. Children who attend Ruston School and Fern Hill School in the early 1900's will be identified and, hopefully, followed to determine whether their mortality patterns differ from one another, or from expectation based on U.S. mortality rates. If childhood exposure to inhaled arsenic causes lung cancer in adult life, this study should be able to document it.

In the next year, I hope to develop ~~more~~ current normal or background arsenic information for urinary arsenic levels by sampling unexposed populations and populations whose direct exposures to arsenic ceased over 30 years ago.

In summary, studies of communities around well characterized sources of pollution offer the best chance for understanding health-pollution relationships. Our studies, of course, would be impossible without the cooperation of the Tacoma smelter, which provides historical arsenic dose information as well as mortality information for its workers. The situation in large urban areas, in contrast, is so complex as to defy understanding.

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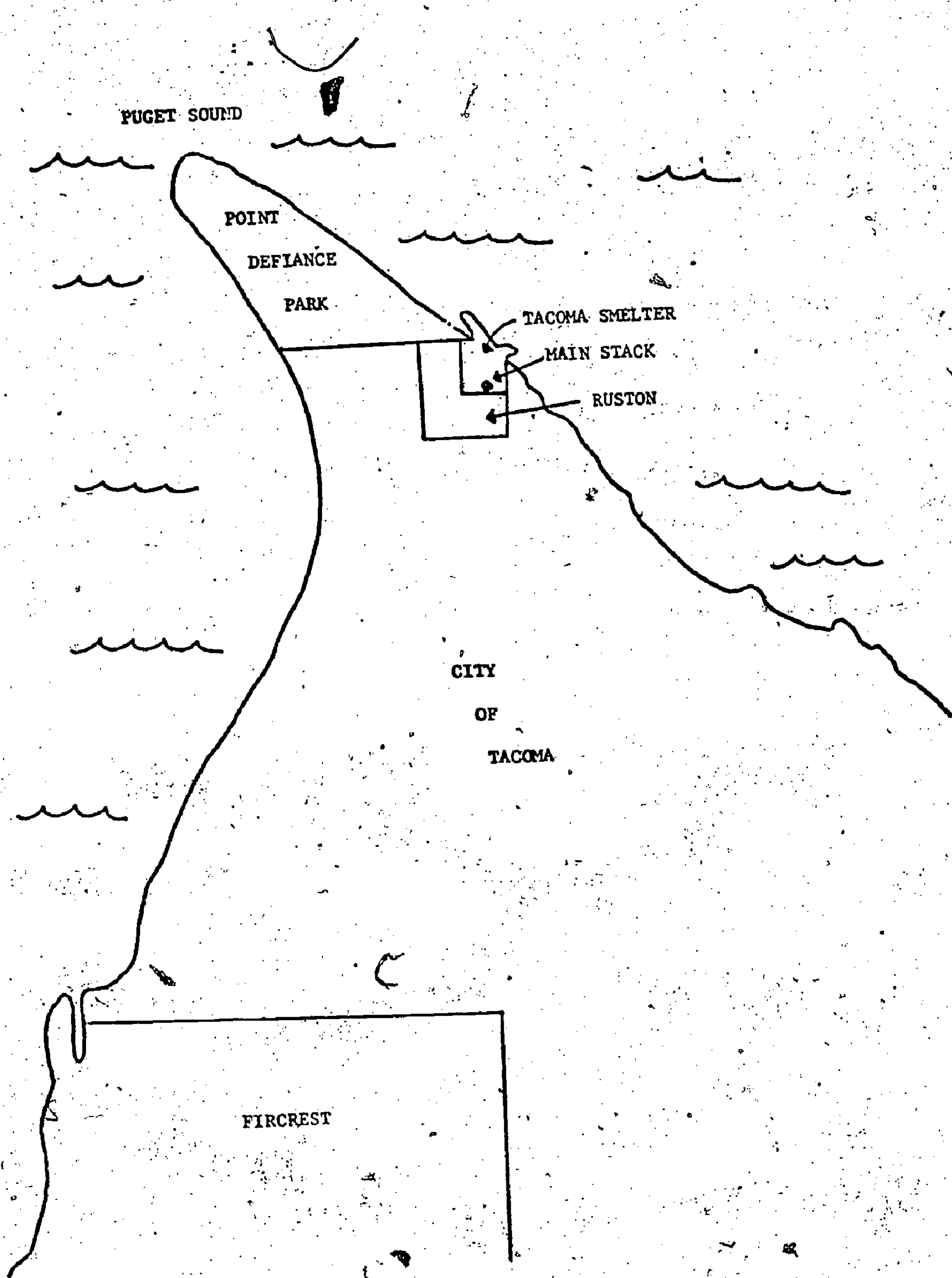

Figure 1. Location of Tacoma Smelter and Ruston In Relation to the City of Tacoma

TABLE 1

AVERAGE URINARY ARSENIC LEVELS (PPM)

During and After Strike at the
Tacoma Smelter 1974

	DURING			AFTER		
	7-19-74	7-25-74	Average	8-20-74	8-22-74	Average
Child 1	.17	.34	.25	.68	.63	.655
Child 2	.27	.07	.17	.16	.41	.285
Child 3	.01	.08	.045	.11	.06	.085
Child 4	x	.14	.14	.10	.13	.115
Child 5	.01	.04	.025	.03	.05	.04
Child 6	.01	.04	.025	.04	.08	.06
Child 7	.04	.08	.06	.09	.10	.095
Child 8	.03	.08	.055	.06	.05	.055
Child 9	x	.06	.06	x	.22	.22
Child 10	.02	.01	.015	.02	.03	.025
ALL			.08			.16

Normal urinary arsenic = .015-.020 ppm.

TABLE 2
URINARY ARSENIC (micrograms per liter)

Sampling date	Number of individuals sampled	Group Studied	Minimum	Maximum	Average
6-6-72	19	Ruston School	10	150	81.8
6-7-72	16	Fern Hill School	10	50	20.0
6-7-72	9	Ruston Preschool Children	40	620	270.0
9-12-72		Traverse Study of Ruston and Tacoma within:			
	7	.5 mi. of stack	50	620	300.0
	8	.5 - 1.0 mi. of stack	50	420	190.0
	6	1.0 - 1.5 mi. of stack	40	140	80.0
	5	1.5 - 2.0 mi. of stack	40	100	60.0
	6	2.0 - 2.5 mi. of stack	N.D	50	20.0
	5	2.5 - 3.0 mi. of stack	10	100	46.0
	5	3.0 - 3.5 mi. of stack	10	50	34.0
	10	3.5 - 4.0 mi. of stack	10	110	48.0
10-11-72 10-23-72 10-30-72 11-6-72 11-13-72	14	Ruston Children Average of 5 weekly samples	20	470	99.0
9-18-72	107	Ruston School Children	N.D.	430	81.0
10-25-73	106	Ruston School Children	10	470	55.0
7-19-74	8	Ruston Children (Smelter on strike)	10	270	70.0
7-25-74	10		10	340	94.0
8-20-74	9	Ruston Children (after Smelter strike)	20	680	143.0
8-22-74	10		30	630	176.0
6-3-75		Ruston School Children			
	5	Seafood ingestion	30	190	102.0
	36	No seafood ingestion	20	660	87.0
6-3-75		Fern Hill School Children			
	13	Seafood ingestion	10	270	62.0
	48	No seafood ingestion	10	230	25.0
11-17-75	102	Ruston School Children	10	200	40.0
	17	Seafood ingestion	10	150	68.0
	85	No seafood ingestion	10	200	35 0
7-23-thru 8-1-76	10	Ruston School Children for 10 days each	20	890	114.0
8-26 thru 9-1-76	6	Ruston Preschool Children for 7 days each	10	400	122.0
11-30 thru 12-3-76	7 (21 samples)	Ruston School children	60	170	101.9

Normal urinary arsenic = .015-.020 ppm or 15-20 micrograms per liter;
N.D. = not detectable

TABLE 3
URINARY ARSENIC (PARTS PER MILLION) FOR RUSTON SCHOOL CHILDREN

	Age	Date/Day										Average
		7/23 Fri.	7/24 Sat.	7/25 Sun.	7/26 Mon.	7/27 Tues.	7/28 Wed.	7/29 Thur.	7/30 Fri.	7/31 Sat.	8/1 Sun.	
Family No. 1												
Child 1	10	.03	.03	.02	.05	.02	.08	.08	.03	X	X	.043
Child 2	9	.03	.08	.04	.06	.07	.04	.04	X	X	X	.051
Child 3	12	.03	.04	.04	.04	.03	.03	.03	.01	X	X	.031
Family No. 2												
Child 1	8	.16	.11	.05	.08	.13	.26	.11	.08	.10	.07	.115
Child 2	10	.04	.08	.04	.07	.07	.06	.09	.04	.05	.11	.065
Child 3	6	.14	.22	.10	.17	.12	.22	.07	.06	.19	.07	.136
Family No. 3												
Child 1	6	.05	.11	.03 SF	.59	.13	.04	.18	.15	.20	.80	.228
Child 2	9	.09	.10	.09	.06	.07	.18	.17	.06	.17	.19	.118
Child 3	10	.04	.10	.03	.05	.10	.08	.06	.07	.04	.46	.103
Child 4	7	.10	.09	.06 SF	.20	.06	.11	.14	.17	.20	.89	.202
Average		.071	.096	.050	.135	.080	.112	.097	.074	.136	.370	.114

SF = ate salmon
X = no specimen

INDUSTRIAL TOXINS AND THE COMMUNITY

Control of PCB's at the Local Governmental Level

Mayor Francis X. McCloskey

Probably one of the most significant challenges facing local governments is developing and maintaining the capability for reasoned policy response to unprecedented problems caused by scientific and technological innovation. Size and resources of the government most closely involved may have little or no relation to the scope or complexity of the problem.

Mayors, council persons, and managers of peaceful midwestern and southern towns are traditionally viewed as being preoccupied with potholes and trash pickup, but more and more their resources are likely to be strained by the unprecedented and unpredictable dynamics of scientific and technological innovation.

Bloomington, Indiana, for example, over the last 2 years has become ensnarled with the implications of being one of the 12 areas of highest Polychlorinated Biphenyls (PCB's) in the United States.

I would like to say a few words about Bloomington, a community of some 50,000 residents nestled in the rolling hills of southern Indiana. Bloomington is the seat of Indiana University, in a setting where a very large lake, state parks, and beautiful woods abound. For many, the community is the inspiration and base for alternative lifestyles which often include a pleasant detachment from the "outside world."

For some residents, this feeling of detachment and idyllic expectations was substantially destroyed with the news that PCB's emanating from the local Westinghouse plant were widespread throughout the community's environment. The Westinghouse Corporation began dumping PCB's into the environment in 1957, when an assembly division for producing industrial and commercial transformers and capacitors was located in Bloomington. The dumping continued in significant quantities until late 1976, when Westinghouse substantially complied with an abatement order of our Utnilties Service Board (Appendix). This abatement order was developed by the Board at my request, after it became obvious that Federal regulatory powers for this problem were nonexistent.

Production of the transformers and capacitors at Westinghouse required a fluid (commercially produced by Monsanto and known as an aroclor) containing the PCB's. The fluid was used to resist flame hazards within the manufactured device; it has a very high kindling point (2300°F) and is very stable. The fluid was allowed to flow directly into the city of Bloomington's west interceptor sewage line leading to Bloomington's Winston-Thomas treatment plant.

The city of Bloomington became aware of the problem in the fall of 1975, following an article in Sports Illustrated and after utility technicians returned from a U.S. Environmental Protection Agency (EPA) sponsored conference in Chicago.

Early in 1976, sampling and testing by the EPA, the State Board of Health, and our city laboratory showed a PCB concentration of 2 to 6 parts per million in effluent from Westinghouse's main sewer. Dried sludge at our Winston-Thomas plant was found to contain from 200 to 500 ppm. Digesting sludge had 900 to 1700 ppm. Raw sewage had 50 to 450 ppb. Effluent entering Clear Creek from our Winston-Thomas plant had 20 to 40 ppb. Accumulation occurred in Clear Creek fish with levels ranging as high as 41 ppb.

Among those most startled by the PCB revelations were various people who over the years had taken sludge from the south treatment plant for use as a garden conditioner. To quote from a report by A. K. Lindben:

> "For a number of years dried sludge had been given away to citizens in the district for use as a soil conditioner in their gardens. When the PCB content of the sludges became known, people were invited to submit soil samples to the laboratory for analysis. While about 40% of the soil samples contained PCB's in the 0 to 4 ppm range, 20% ranged from 5 to 20 ppm range. A few samples contained higher concentrations of PCB's. These gardeners and farmers then became faced

with the problem of removing their top soils or closing those areas to future production of garden products. Some grazing land was affected too.

"Fish caught about 9 miles downstream from the sewage treatment plant were analyzed at a State laboratory. PCB concentrations in the tissues ranged from 50 to over 200 ppm, rendering the fish inedible. The State Board of Health issued warnings that fish caught in the stream and in another stream nearby should not be eaten. The State Board of Health also found it necessary to ban the sale of milk by certain dairies where milk was found to contain up to 13 ppm PCB's. Most of the latter PCB's originated, however, from PCB-containing paint coatings used to line silos for storage of feed grains. Following the bans, a bill to assist dairy farmers who are put out of business by PCB's was introduced and passed in the State Legislature. The bill, at this stage, did not provide for compensation to municipalities for fear of killing the entire bill."

Another concern, of course, is bodily contamination by ingestion of PCB-tainted materials. The same report states:

"Since the problem became exposed, a number of city sewage plant workers had small sections of body adipose tissues taken for analysis. The results showed PCB's in the low ppm range in the samples. The same workers as well as other city employees had blood tests and liver biopsies performed by the National Institute for Occupational Safety and Health (NIOSH). PCB's in the low ppb range were found. In late January, 1977, many families in the district signed to receive free physical examinations by the U.S. Public Health Service doctors. A medical team from the Federal Communicable Disease Center (CDC) in Atlanta, Georgia, arrived during the latter part of February, 1977, to set up a testing laboratory at the local hospital in preparation for the medical examinations."

Various Westinghouse employees have been examined by NIOSH physicians. Representatives from the U.S. Center for Disease Control in Atlanta during a visit here advised that reported levels were not alarming. But the simple fact is that no one knows the possible long term deleterious effects.

Perhaps the most obvious and vivid result of the PCB situation in Bloomington is some 1,800 tons of contaminated sludge piled up at our south treatment plant. The PCB-content of this sludge is 200 to 450 ppm. The State Board of Health will not issue a permit for any method of disposal in the state, including incineration, sanitary land-filling, or chemical fixation.

In essence, Indiana has said, get rid of the sludge but you can't do it in Indiana. Our Utilities Service Board still is searching for a functional solution, while intending to hold Westinghouse liable for the costs of disposal and for all other actual damages to the system.

Costs of disposal of the sludge could total in the several hundreds of thousands of dollars. In addition, the major interceptor lines and the Winston-Thomas plant have been contaminated, as have other lines. Also, grit or particulate matter is shipped weekly to a sanitary landfill in Illinois at a cost of some $25,000 yearly.

The Utilities Service Board and an attorney representing the city are presently negotiating with attorneys for Westinghouse. The basic policy position of the city is that the firm should pay for all costs it has imposed on the system and on the public.

The Environmental Management Board of the state also convened a hearing--presently in indefinite recess--to consider legal responsibilities and overall solutions to the PCB problem. It was recommended Westinghouse and the city should make every effort to reach a settlement.

It should perhaps be noted that the economic resources of a multinational corporation and its legal and other expertise likely give overwhelming advantage to the corporation in dealing with potential litigation against almost any locality.

Considering the limited resources of Bloomington, even given the fact we have an activist administration, a good city chemist, an excellent lab, and the ability to draw on expertise in the University community, our response to this unprecedented situation was overall quite reasoned.

Still, our ability to respond to an unprecedented situation and our leverage in dealing with the problem were hampered by lack of legal backing at the national level and lack of staff assistance at the state level. And with no law or regulation on the Federal books as to nonpoint sources of toxic pollution, our Utilities Service Board was forced to go to a local ordinance as leverage in regulating a national corporation.

Our administration was subjected to some economic and political pressures by the Westinghouse firm, which included a large turnout of employees against "closing the plant," an action which never was seriously contemplated. Westinghouse officials also were quick to point out publicly and privately that it was unfair for Bloomington to impose standards if other communities were not doing the same on their competitors. In essence, it is very difficult for a local government to impose environmental and/or economic controls on a national industry.

Even years after the PCB controversy has been receiving national attention, the EPA has not promulgated rule 307B of the 1972 Water Pollution Control Act. Just last week the Chicago office of the EPA said it was in favor of ~~this~~ regulation, but the national EPA still has not acted.

Such situations as the one in Bloomington put a premium on expeditious development of policy, particularly on the national level, and on intergovernmental cooperation at all levels.

State governments also should turn more to staff for expert advice and technical resources for local communities--many of which do not even have the moderate technical resources of a community such as Bloomington.

Also, the Federal government should provide the sites and funding for disposal of such contaminated wastes. Congress could decide whether funding should be from general revenues or from taxes on particular polluters.

Appendix — Order - Utilities Service Board
Bloomington, Indiana

The Utililities Service Board of Bloomington, Indiana, on the basis of statements and testimony made to it at its meetings and also on the basis of reports and communications from other governmental agencies, including the Environmental Protection Agency, the Indiana State Board of Health, the Indiana Stream Pollution Control Board, and the Environmental Quality and Conservation Commission of the City of Bloomington; and also on the basis of its own staff reports and laboratory analysis; and also on the basis of published articles and findings of both scientific and general interests now make the following findings, conclusions and order:

FINDINGS OF FACT

1. PCBs (Polychlorinated Biphenyls) are compounds that are most often found in concentrated form in manufactured askerals.

2. The possibility exists, on the basis of laboratory experiments and clinical analysis, that the ingestion of PCBs may be a cause of pathogenic disturbances and failures in human beings and other animals.

3. PCBs cannot by any feasible and reasonable process be removed from sewage and remains present in the sludge when it exists in raw sewage.

4. The City of Bloomington and its Utilities Service Board are responsible for the safe and economical disposal of accumulated sludge from its sewage treatment plants.

5. The City of Bloomington and its Utilities Service Board discovered, as a result of reports of a conference held in Chicago in November, 1975, a possible danger from PCBs in human environment.

6. Upon receipt of these reports the Utilities Service Board ordered sludge retained at its plant until further findings.

7. Prior to this order the Utilities Service Board had encouraged and engaged in the practice of giving and delivering to persons the processed sludge from its plant for soil conditioners and fertilizer; a practice that it had found to be both economical and mutually beneficial to it and the recipients.

8. There exists reasonable proof that the continued disposal of sludge as soil conditioner will result in the release of PCBs into the environment to such an extent that human beings in the Bloomington area may ingest PCBs in abnormal quantities.

9. Persons who formerly were willing to take and accept delivery of sludge no longer will accept it.

10. The Utilities Service Board has received citizen complaints and threats of legal action because of the existence of PCBs in sludge as it was formerly deposited.

11. The cost of alternative means of disposal of sludge is unreasonably high to be a normal sewage treatment operation.

12. The existence of PCBs in the Bloomington sewage system and sludge at the Winston-Thomas Treatment Plant is almost entirely the result of the depositing by the Westinghouse Electric Corporation from its Curry Pike plant into the City sewage system.

13. The continued discharge of RCBs by Westinghouse Electric Corporation into the public sewers of Bloomington interferes with the proper operation of the Winston Thomas sewage treatment plant by making uneconomical the disposal of its sludge.

14. Westinghouse Electric Corporation is installing new processes to alleviate the discharge of PCBs into the sewerage system of Bloomington and that December 1, 1976 is a reasonable date for the completion of this installation.

15. The Environmental Protection Agency is now preparing for comment a proposed regulation (to be issued in conformance with PL 92-500 requirements) for reduction of PCB levels in effluent under Section 307 (a) of the 1972 Water Pollution Control Act Amendments limiting discharge of PCBs into public sewerage systems.

CONCLUSIONS

1. The Utilities Service Board of Bloomington has the jurisdiction and responsibility to enforce ordinances of the City of Bloomington, including Title 10 of the Bloomington Municipal Code and specifically 10.08.040 Prohibited Discharges.

2. The existence of the abnormally high quantities of PCBs in the sludge of the Winston Thomas plant at Bloomington interferes with the proper operation of that plant within the meaning of 10.08.040 (7).

3. PCBs in a greater concentration than that to be permitted under the proposed regulation (to be issued in conformance with PL 92-500 requirements) for reduction of PCB levels in effluent under Section 307 (a) of the 1972 Water Pollution Control Act Amendments is a prohibited discharge under 10.08.040.

ORDER

WESTINGHOUSE ELECTRIC CORPORATION, having been found to be in non-compliance of 10.08.040 (7) of the Municipal Code of the City of Bloomington by its discharge into the public sewers of polychlorinated biphenyls (PCBs), is ordered to cease permanently the discharge of PCBs over the amount to be set forth in the proposed regulation of the Environmental Protection Agency to be issued for industrial discharge into sewerage systems in conformance with PL 92-500 requirements, regulations for reduction of PCB levels in effluent under Section 307 (a) of the 1972 Water Pollution Control Act Amendments on and after the <u>first</u> day of <u>December</u>, 1976.

IT IS FURTHER ORDERED that the Utilities Service Board will review the standard of the proposed regulation of the Environmental Protection Agency, to be issued for industrial discharge into sewerage systems in conformance with PL 92-500 requirements, and reserves the jurisdiction to modify the order in such a manner that would not impose a more difficult standard on Westinghouse Electric Corporation than the standard of the proposed regulation of the Environmental Protection Agency.

This order was adopted by the Utilities Service Board of Bloomington, Indiana, at its meeting held July 2, 1976.

(s)
Robert P. Schmuhl, President
(s)
H. Jack Martin

Flo Davis
(s)
David L. Dilcher
(s)
Richard W. Fee
(s)
John M. Miller
(s)
William B. Milne

INDUSTRIAL TOXINS AND THE COMMUNITY

The Role of the Occupational Physician in Controlling Industrial Toxins Outside the Working Environment

Maurice Johnson, MD

I appreciate the opportunity to talk with you about toxic chemicals in the environment and, more specifically, about the role the occupational physician plays in their identification and control. Let me say first, I think the physician's role in this regard has been a small one. As I see it, that is a regrettable situation and one that should be remedied. I hope we can spend a few minutes looking at the reasons why the occupational physician plays this limited role, and at some of the reasons why the physician should have a more substantive involvement in the control of chemical exposures outside the workplace.

I think it is obvious to everyone that the occupational physician has played a major part in the setting of safe standards for the workplace. A review of the literature on any of the common toxic chemicals to which workmen are exposed will inevitably demonstrate the intimate involvement physicians have had in the identification of hazardous working environments and in the establishment of safe levels of exposure and effective methods of control.

On the other hand, when one looks at the background data which supports many of our general environmental standards, one sees that the practicing occupational physician has had very little input into these determinations and that the major input has come from experts in other biological and social sciences. The epidemiologist, the toxicologist, the statistician, the chemist, and a host of others have played a much more important role.

It is, of course, true that considerations which are applicable to the workplace do not automatically extend to the general environment. Populations at risk are quite different. The occupational physician sees in the plant a selected group of employees who are by and large healthy. They usually spend not more than 8 hours each day in the working environment, and they have substantial rest periods between exposures, which gives opportunities to recover from minor physiologic insults.

Exposures to which the general population are subjected are of quite a different nature. They may be 24 hours per day, 7 days per week, often year in and year out. They affect all age groups, from the infant to the very old, and expose not only the well population but those who suffer from a variety of acute and chronic diseases.

Given this disparity in exposed populations and the obvious need for different permissible levels of exposure to a toxic material, it is perhaps not surprising that many occupational physicians see the permissible exposure levels for compounds in the community as ridiculously low. Many who are concerned with community health see the levels which are permitted in the workplace as excessively high.

The recent case of vinyl chloride (VC) exposures, with which I am quite familiar, is a good example of this point. There is no question exposures in the workplace in years past were excessively high and resulted in a number of cases of angiosarcoma of the liver which, without doubt, can be attributed to vinyl chloride exposure.

About 60 such cases have been recorded in the world since the first cases were reported in 1974. These have been the results of exposures which date back as far as the beginning of the VC industry in about 1935. The levels to which these men were exposed are not well documented, but surely they were several parts per million, with occasional excursions into the thousands of parts per million.

During the years that these exposures were occurring, there was of course a release of vinyl chloride into the general environment around the plants, and there has been considerable effort to discover what the community exposure levels were and whether or not there was any resulting disease. The best estimates of the community levels in past years probably came from the U.S. Environmental Protection Agency (EPA) which estimated those levels to average 17 parts per billion.

Investigation of the population living around these plants has shown no excess of angiosarcoma of the liver and generally no health effects that can be related to VC. Thus it appears that while past practices resulted in clearly hazardous in-plant exposures, they produced no discernible health effects in the community.

Today the permissible exposure level in the workplace has been reduced by regulation to 1 part per million and the emission standards promulgated by EPA last fall will reduce the level in the environment around the plant to about 2 parts per billion. Although there might be a few dissenting opinions, surely the overwhelming consensus among knowledgeable people is that the 1 ppm standard in the workplace very adequately protects against VC-induced disease. While we will probably see the results of past exposures producing health effects on workers for some years to come, I think we are all quite confident that VC is indeed being handled safely in the workplace today under current regulations.

In the matter of community exposures to VC, the situation is quite different. As I mentioned before, in 1976 EPA promulgated regulations which would lower the VC level in the community from 19 ppb--a level which has not been shown to have any adverse health effect at all--to 2 ppb, providing thereby a safety factor at least 8 times over a level which, as far as anyone can tell, was already perfectly safe.

While this would seem to me to provide more than ample protection for the community, not everyone shared this view. Indeed, the Environmental Defense Fund (EDF) sued the EPA in an effort to force a further reduction in the permissible VC emissions from plants. I don't want to dwell today on the futility of the proposal made by EDF, although I should note for the sake of completeness that only a small portion of the VC monomer which escapes from a manufacturing plant does so via the exhaust stacks and that reducing the permissible amount by one-half, as EDF has suggested, will reduce community levels by less than 1 ppb and will of course have no resultant health effects whatsoever.

It is at precisely this point that I think the occupational physician can and should play a much more important role, and I think there are several reasons why he is especially well qualified to do this. First, the physician has a good knowledge of the health effects which can be reasonably attributed to the chemical and the scientific background on which to judge whether or not there is a threat to the community's health.

Second, the occupational physician is thoroughly familiar, and deals every day, with the dose response relationship and thus can recognize that depending on dose, the same material can be a poison, a medicine, or have no effect. This seems to be a concept that is very difficult for the general public to accept, although it is one we all use regularly. For example, if we have a headache, we take 2 aspirin tablets; we don't take half a tablet, because we know that would be ineffective; we don't take 20 tablets, because we know we would at least have an upset stomach; and we don't take 200 because we know this might well be fatal. We take the 2 aspirin tablets with considerable confidence they will relieve the headache without significant side effects.

Another contribution the physician can make to the selection of suitable community levels for toxic materials is based on the fact that his training and daily experience allow him to be comfortable with the best compromise in the given situation, as opposed to the ideal solution to a problem. For example, if a patient has acute appendicitis, the best solution to the problem is for the inflammation to spontaneously subside. However, in the real world that does not happen, and the physician must then advise his patient in choosing between a variety of alternatives which carry varying risks. When the physician recommends surgical removal of the appendix, he believes this is the best recommendation and is not disquieted by the fact that there are anesthetic accidents, wound infections, pulmonary emboli, and a host of other complications which represent real, although remote, hazards. I think that our society has not been able to deal with this problem of risk-benefit relationships in environmental matters. We don't seem to have a problem with risks and benefits in setting highway speed limits, but we are very uncomfortable with the thought that we could permit an environmental exposure which might pose even the smallest risk. I think the occupational physician is in a unique position to bring a sense of balance into these considerations and to help set standards that are prudent, yet reasonable.

Perhaps one of the reasons occupational physicians have not been more active in these environmental affairs is that they don't always involve only weighing one health problem versus another, but that often there are social and economic considerations which must go into the equation. I think that occupational physicians are somewhat reluctant to speak out in these circumstances, although surely in the modern practice of medicine, as with the changes that are being proposed, socioeconomic considerations are very much in the minds of physicians as they make daily decisions.

Let me go back to my illustration of the appendectomy with its remote possibility of complications. If a young, generally health patient presents acute appendicitis and a routine appendectomy is performed, we expect the patient to go from the recovery room back to the general surgical service. We do not expect the physician to assign this patient to an intensive care unit for 2-3 days. This is not to say that the nursing care on an intensive care ward is not better. It clearly is. The fact is that we recognize the probability of complications benefiting from such expensive nursing care are so remote that it is not justifiable.

I think the time has come when, in the area of environmental health problems, occupational physicians must begin to take a similarly forthright stand. We cannot ever prove that a given environment is totally safe, but we can establish that some levels of environmental contamination with toxic materials are so unlikely to cause health problems that the results are acceptable.

Most of what I said today reflects my personal position, but I do feel strongly that the occupational physician must expand his concern beyond the plant and take an active part in considering safe levels of community exposures. I think the occupational physician not only has a clear contribution to make, but also has a clear obligation to make it.

INDUSTRIAL TOXINS AND THE COMMUNITY

The Michigan PBB Incident

Kenneth R. Wilcox, Jr., MD, Dr.PH

One of the problems that must be faced is the consequence to the community of useful chemicals getting into the wrong places. We are accustomed to considering the consequences of producing or using a chemical in terms of its proper intended use. However, when chemicals are misused there may be dire consequences to our communities and to the general public. This paper describes an incident that has caused widespread and serious problems within the State of Michigan (1,2).

DESCRIPTION OF INCIDENT

Among the chemicals produced at the Michigan Chemical Company were two having somewhat similar appearances but widely different properties. This company was a major producer of polybrominated biphenyl (PBB). This product was made by the bromination of biphenyl compounds and has been used as a fire retardant substance, particularly in plastics. It is an extremely stable substance that is relatively insoluble in water but highly soluble in fat. Since it is ordinarily incorporated into finished products the exposure to the general public of this product is ordinarily of no consequence.

Another chemical produced at the company was magnesium oxide. It has been found that magnesium oxide in many instances will stimulate milk production, and it is therefore a useful additive to some special dairy cattle feeds. Thus, this compound enters the food chain, and the potential for an undesirable exposure of the public if the magnesium oxide were mistakenly replaced by or contaminated with a harmful chemical is very great.

In early 1973, because of a paper shortage, there was a delay in the receipt of preprinted bags by the chemical company. During this period, the trade names of the compounds were stenciled on the plain brown bags used. PBB was sold under the trade name of

Fire Master and magnesium oxide under the trade name of Neutra-Master. At this time an estimated 10 to 20 fifty pound bags of Fire Master were sent by mistake to the Farm Bureau Services as fulfillment of an order for Neutra-Master. This mistake was not recognized, and the PBB was used in the production of feed for dairy cattle.

In the fall of 1973, some dairy farmers began experiencing health problems with their cows but the difficulty was not generally recognized for some time. One of the dairy farmers, who had been a chemical engineer, was convinced that the feed was the problem and persisted for months in an attempt to determine what harmful compound might be in it. It was not until April 1974 that analysis confirmed the presence of PBB in the milk and feed from the suspected farm. The earlier mix-up was then quickly discovered. Because the mistake was not discovered for approximately one year, there was extensive contamination of food products.

As expected, PBB was discovered in beef and also in milk and milk products such as cheese and butter. In addition, because of the contamination of farms and incidental uses of the feed, there was also contamination of swine, sheep, chickens, and eggs. Attempts were made immediately to begin removing contaminated products from the market, but it was not until late 1974 or early 1975 that the market was essentially cleared of products containing PBB at concentrations above the FDA guideline. There still remain rare samples of beef with traces of PBB, but the significant exposure through our food chain is essentially past.

EFFECTS OF PBB ON COWS

The effects of PBB on dairy herds were rather complex and confusing because of the uncertainty of the effects of other intercurrent health problems (3). However, among those highly exposed, it was clear that toxic symptoms in cattle included refusal of feed, decreased milk production, acute anorexia, shrinking of the udders, breeding problems, extension of gestation period, and stillborn calves. In addition, many of the cows had lameness, swollen joints, abnormal hoof growth, and hyperkeratosis. Some had matting of hair, hair loss, hematomas, and superficial abscesses. In severe cases there was weight loss, wasting of muscles, particularly in the hind limbs, coma, and death. Experimentally, heifers were not affected by a dose of 250 miligrams per day for 60 days but were affected by 25 grams per day (4). Those heifers receiving the higher dose showed anorexia, excessive lacrimation and salivation, diarrhea, emaciation, dehydration, depression and abortion. Signs developed progressively in these heifers. Thus, it is clear that higher doses of PBB are toxic to cattle.

EXPOSURE OF PEOPLE

The extent of the exposure of the people within the State of Michigan to PBB has gradually unfolded. Efforts in 1974 were concentrated on those farms with demonstrated contamination of their cattle with PBB, the quarantined farms. In the initial studies of these farms, PBB blood levels were determined for a sample of quarantined farm families and in a sample of nearby farm families that served as a comparison group.

Table 1. Blood PBB levels in participants of 1974-75 study

PBB blood levels*	Quarantined farms				Nonquarantined farms			
	Adults		Children		Adults		Children	
	No.	%	No.	%	No.	%	No.	%
0	3	3.7	-	-	21	28.4	-	-
0.002 - 0.019	43	52.4	8	28.6	52	70.3	29	96.7
0.02 - 0.09	19	23.2	10	35.7	1	1.4	1	3.3
0.1 - 0.49	11	13.4	3	10.7	0	0	0	0
0.5 - 2.26	6	7.3	7	25.0	0	0	0	0
	82	100.0	28	100.0	74	100.1	30	100.0

*Measured in parts per million (ppm)

On the quarantined farms, only three of 110 persons tested had blood levels below the level of quantitation. Thirteen of these individuals had levels over 0.5 ppm with the highest being 2.26 ppm. Clearly, this group had a substantial exposure. However, on the non quarantined farms, there were only 21 of 104 subjects tested that had blood levels below the level of quantitation. The remainder had levels below 0.1 ppm. Thus, the level of exposure was lower on the non quarantined farms, but there was still a substantial number of persons with documented exposure to the chemical.

In early 1975, we began offering routine PBB analysis of specimens submitted by physicians. The circumstances that prompted physicians to submit specimens have varied greatly, and there is a mixture of individuals with and without symptoms, and persons with and without known exposure to PBB-contaminated food. In this unselected sample, about half of the individuals had PBB blood levels below our level of quantitation, 1 ppb. However, some individuals had levels as high as 2 ppm. Such blood testing made it apparent that a substantial portion of the population had been exposed to the compound.

A little reflection on the nature of PBB leads one quickly to appreciate that a fat soluble substance like this will tend to concentrate in the fat at much higher levels than would be found in the blood. Fortunately, many of the specimens submitted by physicians were fat biopsies. This enabled us to examine the relationship between the PBB in the blood and in the fat biopsies taken on the same day. A total of 181 such paired specimens have been analyzed. In this group there were 66 specimens in which the blood level was quantifiable at 1 ppb or greater. Analyses of the paired specimens on these individuals show that there is a very high correlation (R = .96) between the blood and fat levels (Fig. 1).

We now feel that, in general, the concentration in the fat will be approximately 300 times the concentration in the blood, but of course the fat to blood ratios may vary by individual. The adipose PBB levels varied from non detectable to 1.2 ppm in the other 125 individuals not having a quantifiable level of PBB in their blood.

Table 2. Adipose tissue PBB levels for persons having 1 ppb blood PBB

Adipose PBB Level (ppm)	No.
<.03	11
.03	59
.2	32
.4	15
.6	4
.8	1
1.0	3
1.2+	-
Total	125

Most were below 0.6 ppm, with only 8 being above this. Only 11 of this group did not have detectable levels of PBB in their fat. If this were a random sample of our population, it would indicate that approximately 95% of the population had been exposed to PBB.

An additional estimate of the occurrence of PBB exposure in the population has come from analysis of milk samples from nursing mothers. PBB was first detected in breast milk when samples taken for a national study of other chemicals were later analyzed for PBB. Finding PBB in these samples, and in some others obtained for confirmation, led to a study of a random sample of nursing mothers in the state. For this purpose, the state was divided into the Upper Peninsula and Lower Peninsula. Of 53 mothers sampled in the Lower Peninsula, PBB was not detected in the milk of only 2 women.

Table 3. PBB levels in breast milk of women in Lower and Upper Peninsula

PBB range in breast milk	Number of women in study	
Fat in ppm	Lower Peninsula[1]	Upper Peninsula[2]
Total	53	39
Non-detectable	2	23
Detectable up to 0.05[3]	16	13
0.05 up to 0.1	17	2
0.1 up to 0.5	15	1
0.5 up to 1.0	2	-
1.0 and above	1	-

1. The study was restricted to women who delivered between August 15 and August 21, 1976, in one of 147 Lower Peninsula Hospitals.
2. The study was restricted to women who delivered in August 1976 in one of 20 Upper Peninsula Hospitals
3. Counts include 6 Lower Peninsula and 9 Upper Peninsula samples with a trace of PBB

One woman had a value above 1 ppm. In the Upper Peninsula, 23 out of 39 women sampled did not show PBB, and none had values above 0.5 ppm. We estimate that the level in breast milk is approximately 100 times that in the blood, so that this is a more sensitive method of determining than is blood sampling. This study agrees with the estimate that approximately 95% of the persons in the Michigan's Lower Peninsula have had exposure to PBB in sufficient quantity to have detectable levels.

One question that must arise is the significance of the exposure to PBB in 1973 and 1974 to the present concern for the health of the public. One of the characteristics of PBB is its stability and slow excretion rate. The blood PBB levels of 148 persons studies in 1974 was compared with their levels in 1977 (Fig. 2). The results indicate that there is very little, if any, decline in these individuals' blood PBB levels over this 2- to 3-year period. It is difficult to be certain that this actually measures the rate of excretion, because we cannot be sure that there has not been some further exposure in the meantime.

There is some evidence that levels measured in serial fat samples on the same individuals show a declining level. We hope that further studies will confirm this, but it is clear that there is a continuing exposure internally from PBB ingested 2 or 3 years ago. Thus, if there are effects that are slow in appearing, we are not yet in a position to know the final outcome of this exposure.

EFFECTS ON PEOPLE

Initial attempts to determine the health effects of PBB exposure were begun promptly in 1974 when the exposure was discovered. Rapid health assessments and analyses of blood chemistries for such effects as liver function abnormality did not reveal any ill effects. A study involving 50 families from quarantined farms and 50 from nonquarantined farms was begun in 1974. The only health problems affecting more than 5% of the study group were headaches, fatigue, balance problems, anxiety, and some increase in rashes. The frequencies of these problems were not significantly different statistically in the two groups.

When analyzed by PBB blood levels, there was generally a higher frequency of the complaints listed above in subjects having greater than 20 ppb in their blood regardless of quarantine status, but, again, the differences were not statistically significant. Our conclusion was that there was no disease or symptom complex that occurred consistently in those exposed, but that the sample was too small to exclude less frequent, serious problems, or chronic problems that might develop later.

In 1976, a long-term study was begun with a goal of enrolling 4,000 exposed individuals. Enrollment is almost complete at present, but there has not been sufficient time to analyze the data. Preliminary analyses suggest there may be some increased frequency of tiredness and fatigue, neurological complaints such as numbness and tingling, skin problems such as rashes and nail defects, and complaints associated with the joints. It is not clear if these are actually occurring in abnormal frequency or if there is a relationship to PBB exposure.

In November 1976, an intensive examination was done on over 1,000 exposed individuals by the Environmental Sciences Laboratory of Mt. Sinai Hospital, directed by Dr. Irving Selikoff. Final analysis of this study is not yet available, but there were findings of increased frequency of certain symptoms, particularly of gastrointestinal system and joints. Dermatological examinations suggested an increased frequency of rashes. Of particular interest was the frequent finding of a general neurological problem characterized by hypersomnolence, easy fatigability, and loss of memory and of the ability to maintain concentration. These symptoms were not associated with specific neurological signs, but their occurrence was quite striking. Another finding of potential importance was a deficiency in the numbers and functional ability of lymphocytes, particularly T-type lymphocytes, in a sample of 45 persons. The significance of these findings is still under investigation.

The general health assessments of the exposed farmers are that, although many of them have had no significant health problems and have been able to work normally, some have had deterioration in their ability to carry on their usual work. Some farmers have sold their farms because of their inability to continue their work. Some of these farmers have operated farms for many years and have noticed changes only since 1973. Even though the nature and significance of the health changes have not been defined objectively, it is imperative that the studies be continued to determine what effects are due to PBB and what can be done about them.

DISCUSSION

Despite the work that has been done to date to elucidate health problems associated with PBB, we still cannot define with certainty what health effects have occurred due to PBB exposure. We must assume, however, that the complaints and health problems exhibited by exposed individuals may be due to PBB until other explanations are found, or the health effects of PBB are determined. The greatest problem is that people were exposed over a long and variable period, and that people cannot be divided into exposed and unexposed groups. This means that all the health events that normally occur because of a variety of reasons confound the problem of determining the effect of PBB. This is a very difficult problem, but we feel that progress is being made.

The total impact of this mix-up in the shipment of 10 to 20 fifty pound bags of chemical is immense. There has been a large loss of food-producing animals and animal products: approximately 30,000 cattle, 4,500 swine, 1,500 sheep, and 1.5 million chickens have been destroyed. Over 800 tons of animal feed, 18,000 pounds of cheese, 2,500 pounds of butter, 5 million eggs, and 34,000 pounds of dried milk products have been destroyed. Settlements for over 38 million dollars in damages, including loss of animals, have been made, and there are many suits still unsettled.

In addition to the adverse health effects experienced within Michigan that have been attributed to PBB, there has been widespread anxiety among the general public because of the uncertainty of the full significance of this exposure. The state has appropriated at least fifteen million dollars per year for three years to test animals for traces of PBB so that contaminated animals can be destroyed. It is not at all clear what the final cost will be of this incident.

One of the questions that such incidents raise, which is not yet answered, is how to prevent such occurrences. Increased regulation may be useful in some instances, but in our large and complex world it is difficult to see how this can be completely successful. We must somehow make the producers and users of chemicals aware of potential health problems not only from their normal use, but also from incidents of unexpected contamination. This requires intimate knowledge of production processes and handling of the chemicals, and an understanding of potential health effects if the community should be exposed.

Who is best suited to act for the community in this regard? Who is in a position to know what chemicals are processed and how? Who is in a position to appreciate the health significance of the unexpected contamination of compounds often used by the public, with chemicals not intended for public use? Who can understand the covert and overt health effects of chemicals with which industries deal? I propose that the persons attending this meeting, occupational health physicians, are in a position to fulfill these functions.

If the responsibilities and the vision of physicians working in industry can be broadened to consider the potential community effects of chemicals and the possibilities of unplanned community exposure, then industry itself would be in a position to take steps to prevent such occurrences. It is true that not all industries have access to physicians, but yet those with access could perform a service by establishing a continuing review of their operations with the risk to the community in mind. Industry must realize the problem, and physicians working in industry must realize the problem. Unless we establish such methods and responsibilities, we are doomed to future repeated insults to our peoples' health and to our economy by repetition of deplorable incidents like this.

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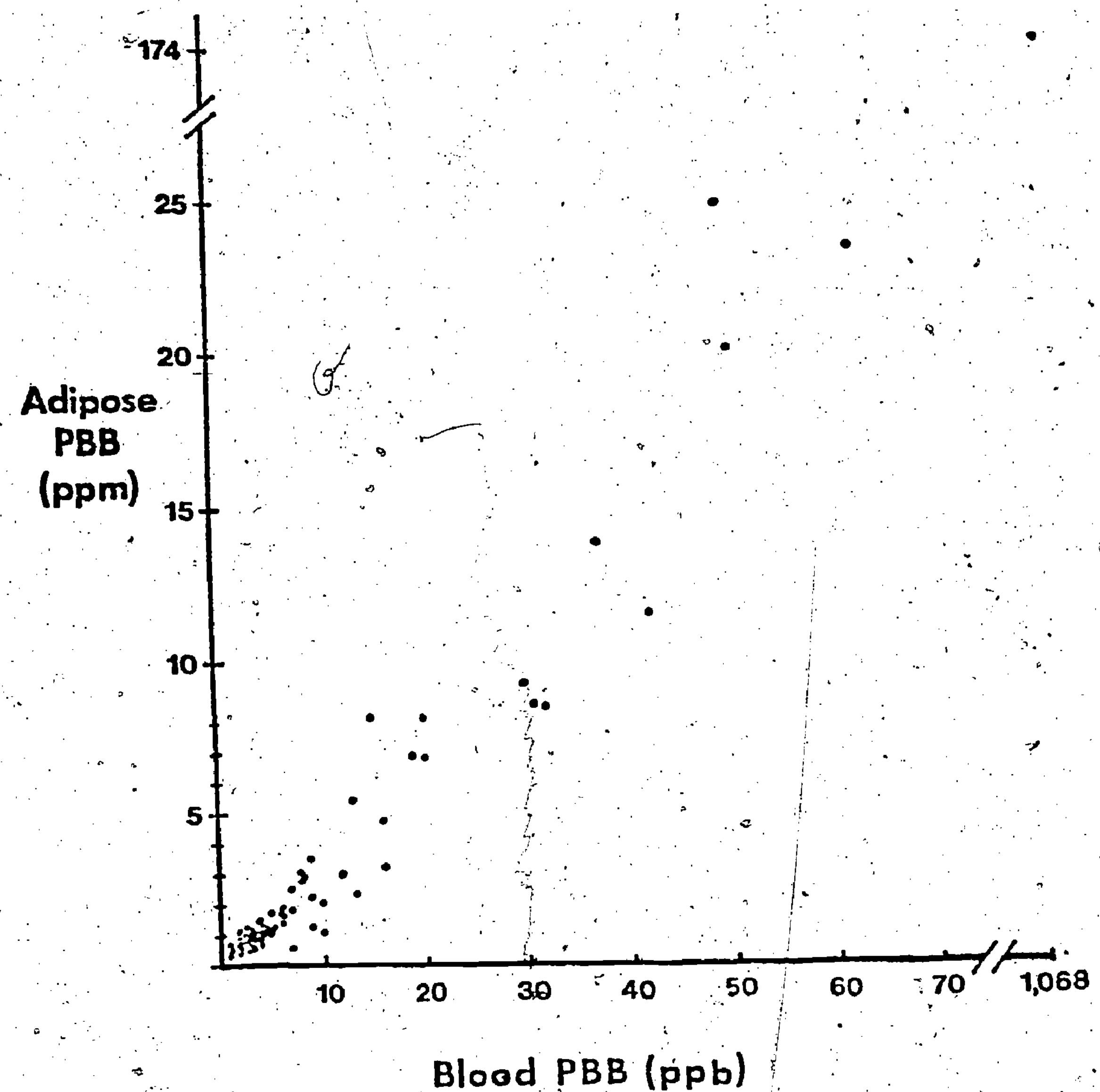

Figure 1. THE MICHIGAN PBB INCIDENT
Relationship between Blood PBB levels
and Adipose PBB levels
(Includes only the 66 subjects whose PBB
values were 1 pbb or greater)

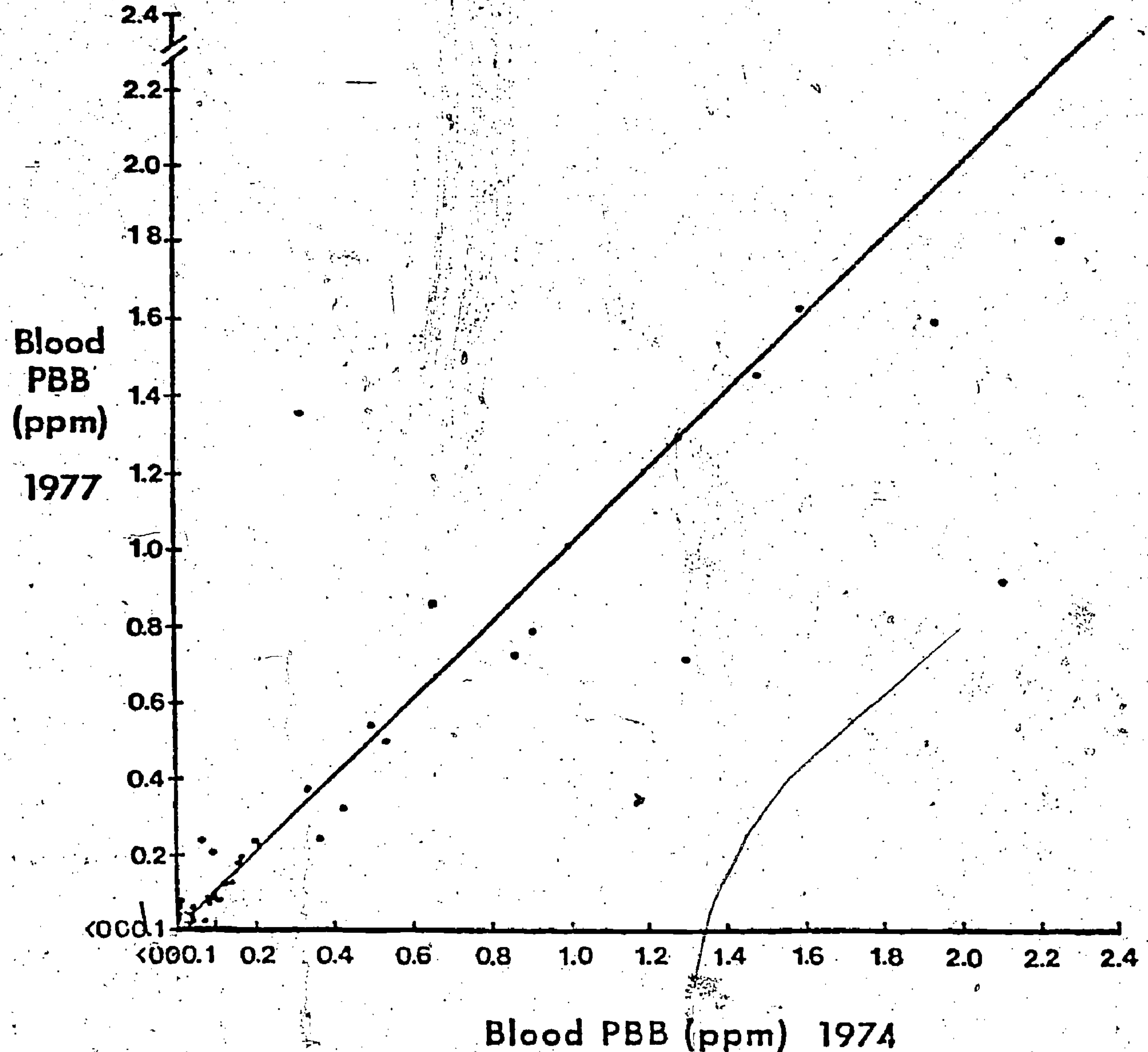

Figure 2. THE MICHIGAN PBB INCIDENT
Blood PBB values for the same subjects in 1974 and 1977

PROBLEMS IN OCCUPATIONAL
HEALTH PROGRAMMING

Introduction

Carl Zenz, MD.

The topic this afternoon is a very broad one. Perhaps with proper planning we should not have problems, but since we are human and face many variables beyond our control, problems do occur.

It behooves all of us to know our own industries and processes and get out into the factories to see what the workers are doing. We must consider the location of the factory and whether it is a new one in a new community, or whether it is an expanding old factory. We should consider the geographic location and climate. The makeup of the work force, the median age, and the sex distribution, are important. We should know whether night work is involved; and whether there is teamwork and cooperation among personnel, including the industrial hygienists, engineers, management, nurses, and physicians.

It is important to be aware of community resources. Perhaps a new factory is planned for a small community which is already short of physicians. But how can the one or two older physicians in a small community do 500 pre-employment physical examinations in a given period of time? Will the physicians learn of problems in the new work force?

Thus, community resources must be considered--the local physicians, the hospitals, and the governmental agencies beginning with city health departments and leading through the state agencies to the Federal level and NIOSH.

PROBLEMS IN OCCUPATIONAL HEALTH PROGRAMMING

The Role of Nursing in Occupational Medicine

Melba M. Gillane
Major, USAF NC

You all know the old cliche, "Jack of all trades, master of none." The occupational health nurse (OHN) must be a jack of all trades and, of necessity, a master of many. This specialty is perhaps one of the most diversified and varied within the nursing profession.

OHNs are concerned with the promotion and maintenance of health, with emphasis on the prevention of disease and injury rather than treatment. They are involved with the entire working community, meaning not only the workers, but also their families and their living and working environments.

The magnitude of the OHN's role is large, for they must be prepared to cope with a variety of situations and problems which arise on a daily basis: for example, the periodic occupational exam; traumatic injury; toxicological exposure; a family crisis; and implementing a worker health education program. This is only a selection of the OHN's responsibilities.

The OHN must be able to perform independently and also as a member of the multidisciplinary occupational health team, comprised of physician, nurse, bioenvironmental engineer, safety engineer, and certain technicians. Relating to people of various disciplines and at different levels of management requires a nurse skilled and educated not only in the basic sciences of nursing, but also in communications, the toxicological aspects of industry, OSHA's requirements, hearing conservation, disaster medicine, ergonomics -- the list continues _ad infinitum_.

You may consider this an idealistic rather than a realistic view of the OHN's true educational preparation. That thinking is partly correct, because in most basic nurse training programs, little if any emphasis is given to occupational health nursing. Many OHNs have attained their skills and education through on job training, self study, or additional college level courses taken to enhance their knowledge of environmental health and occupational medicine.

However, there are some nurses who are well prepared to assume the occupational role, for example, graduates of the Air Force Environmental Health Nursing Residency program and graduates of MS programs in occupational health nursing like that at New York University.

Regardless of the level of preparation, the nurse's role becomes of even greater significance considering they are usually the primary medical people on site at any industrial complex. Hence, the member of the health team in most direct contact with, and most aware of, the overall health needs of the worker is the OHN. Overt or subtle changes in workers often can be observed more readily by the nurse than by any other team member.

To adequately describe the overall role of the OHN would require more time than I have today. Instead, let me take one segment, the periodic occupational physical examination program and demonstrate the responsibilities and contributions of the nurse and the interchange of knowledge and information that occurs with the other disciplines.

Basically, this program is established to examine for any untoward reaction all personnel exposed to hazardous materials in the working environment. Interrelationships among the disciplines begin with the development of this program. The type of examination to be done cannot be determined without input from the bioenvironmental and safety engineers, consisting of types of hazards; TLV's; the organs most affected by the hazard; the degree to which a given individual is exposed; the protective equipment used and so forth. The health team reviews this information and the physician then makes the final decision as to the appropriate exam and special laboratory, x-ray, or hearing tests.

The periodic examination does not always involve a full or partial physical by the OHN, who also can do special testing. But one of the nurse's primary responsibilities definitely will be an updating of the occupational history. Although the worker may fill out a standard form, the nurse interviews to clarify statements made in the history and to gather information that may be pertinent to the worker's future health.

History-taking and interviewing of the worker is the culmination of the skills and educational preparation of the occupational health nurse. Total awareness of the worker as a person, the job performed, and the hazards involved, all are of extreme importance, and even casual statements can be of great significance.

While being interviewed, suppose Mr. Jones makes the statement, "By the way, since I'm here, do you happen to have any aspirin? I've had a headache off and on for seven days, and I just can't seem to get rid of it." This should trigger a warning signal in the nurse's mind. From this should evolve many questions, and follow-up with occupational health team members.

The nurse's immediate thoughts might be: Mr. Jones has a potential exposure to XYZ. Headache can be a symptom of XYZ exposure. Are other people in his area experiencing this symptom? Is there faulty equipment in the area: Is he using protective equipment? Is the headache unrelated to the job, and perhaps related to family problems or to eye problems? What other complaints have brought the worker to the medical facility since the last periodic exam?

Some questions to Mr. Jones might be: At what time of the day or night is your headache more intense? Does medication relieve it, and if so what do you take? Are you being seen by your personal physician for health problems? Are you on any medications? Have any of the other workers in your area complained of headaches? Do you have other symptoms?

Planned follow-up after completion of periodic exam might include total review of the medical record and contact with the bioenvironmental engineer (BEE) and safety team members, with discussion of pertinent facts and findings, perhaps with an equipment check initiated by safety, and a sampling of air in the work area by the BEE.

Since most industrial physicians have several industrial complexes under their care, they are not always on the premises. If this is so in Mr. Jones' case, the nurse should provide the physician with an immediate and detailed telephone briefing about the facts of the problem, pertinent data from the medical record, and actions initiated with other team members.

Thereafter, the physician must be updated continually. Based on engineering or safety findings, the physician may do extensive testing on all people in the area, or perhaps more specific tests on Mr. Jones.

The OHN's responsibilities do not end with notification of the other team members. When the laboratory test results on Mr. Jones are returned, the nurse must decide, for example, if the tests are within normal range or elevated; how the results compare with previous tests; whether there is a progressive increase over several exams, and, is there possibility of chronic exposure? Eventually, if an adverse factor is found, the OHN and the physician must consider health education for the people who work in the area: do they know the acute and chronic symptoms to expect if exposed to the hazard, and are they fully oriented about the use of protective equipment?

No doubt I could relate other interchanges among the team members, but my intent here is to show the extensiveness of the role of the nurse in occupational medicine. From this brief description, I believe it is evident the OHN must be a highly qualified person who is oriented toward several disciplines.

In summary, it is true an occupational health nurse must be a jack of all trades and, of necessity, a master of many.

PROBLEMS IN OCCUPATIONAL HEALTH PROGRAMMING

Professional Liability Considerations

David K. Waugh, Jr., JD

One of the industrial physician's most important responsibilities involves physical examinations of prospective or actual employees. When a physician is employed to do a physical examination in the interest of a third party or corporation, to determine a person's suitability for employment, what is the relationship between the examining physician and the person to be examined?

In Hoover v. Williamson, 236 Md. 250, 203 A.2d 861 (1964), the court said "...there is not a doctor-patient relationship between... a prospective or actual employee and the doctor who examines him for the employer." However, the court also noted the physician may incur liability where he "...undertakes to render services which he should recognize as necessary to another's bodily safety, and leads the other in reasonable reliance on the services to refrain from taking other protective steps, or to enter on a dangerous course of conduct..." If a doctor fails to exercise due care under these circumstances and bodily harm results, the physician can be held liable.

In the case above, the company required annual chest x-ray examinations of certain employees. These were done under the direction and supervision of the defendant physician, who was paid for his services by the company. One of the employees so examined was the plaintiff. The plaintiff employee had worked for the company for a number of years in a job that subjected him to exposure to silica dust. The employee alleged x-ray examinations conducted by the employer clearly showed he had silicosis; and the company's physician misrepresented to him the nature of his condition. As a result, the employee claimed his lung condition worsened and became permanent. The court found the employee's allegations stated a valid cause of action against the physician.

Neither a physician hired by a company to examine employees, nor the company which hires a physician for such purposes, owes a legal duty to the examined employee to discover conditions requiring medical treatment, Lotspeich v. Chance Vought Aircraft (Tex. Civ. App.), 369 S.W.2d 705 (1963). In that case, a physician in charge of a company's medical department interpreted the plaintiff's pre-employment x-ray and noted, "Negative for pulmonary pathology; cardiac shadow within normal limits." It was subsequently found chest x-rays showed a large cavitary lesion in the left chest and evidence of advanced pulmonary disease.

The doctor was employed by the company to determine whether the woman was qualified from a health standpoint to do the work for which she had applied. The court found that the doctor's employment was entirely for the benefit of the company, and that he owed it the duty to perform efficiently. The job applicant didn't select the physician to examine her for her own benefit, and she didn't ask him for a report. "She had no legal right to demand that he exercise any care whatever in conducting the examination, except to avoid injuring her."

While there is apparently no duty to discover conditions requiring medical treatment, a duty does arise where such conditions are discovered. In Riste v. General Electric Co., 47 Wash. 2d 680, 289 P.2d 338 (1955), the plaintiff employee worked for a company maintaining an industrial medical service headed by a physician. The employee was examined on a periodic basis, and x-rays were taken which revealed active tuberculosis in his right lung. The company notified the employee in writing there was nothing wrong with him. The company, knowing he had tuberculosis, assigned him to tasks involving physical exertion, which worsened his tuberculosis.

The court said the case fell within the rule that it is negligence for an employer to knowingly assign an employee to work which is beyond his physical capacity to perform safely. Under this rule, an employer is liable for any injuries caused by such negligence. A defense of assumption of risk or contributory negligence might be available if the injured employee knew of his condition. But in Riste, the employee did not know he had tuberculosis during the time in question.

What if a physician retained by a company incorrectly certifies that an employee is unfit physically for a particular job or purpose? In Armstrong v. Morgan (Tex. Civ. App.), 545 S.W.2d 45 (1976), an employee was requested to have a physical exam in connection with his promotion to a new position. He was examined by a physician employed for the purpose, who was to report the results to the company. The physician's report, indicating the employee was in very bad physical condition, resulted in his losing his job and the benefits attendant to his position. The plaintiff ex-employee brought an action based on negligence, or alternatively, for libel. The court said,"If Doctor Morgan negligently performed the examination and as a result gave an inaccurate report of the state of appellant's health, and appellant was injured as a proximate result thereof, actionable negligence would be shown." The case was remanded to the trial court for a determination of the specific facts.

A different result arises when a doctor fails to qualify his medical findings to a personnel manager. In Beadling v. Sirotta, 41 N.J. 555, 197 A.2d 857 (1964), the plaintiff sought employment as a machinist with the defendant company and was asked to take a pre-employment physical exam including an x-ray. The radiologist to whom the applicant was referred was said to have deviated from proper medical standards in that his report to the plant physician labeled the infiltration on the plaintiff's x-ray as active reinfective tuberculosis, whereas proper conduct would have been to report "infiltration" and to recommend further tests. The applicant argued this breach of good medical practice amounted to negligence resulting in his failure to obtain employment. The court found the radiologist's report did not create an unreasonable risk of harm where "...the negligence alleged so closely approximates a matter of mere semantics."

WHAT CONSTITUTES NEGLIGENCE?

In the cases previously discussed the issue considered was whether or not the physician was negligent. Most professional liability actions are based on some alleged act of negligence. Industrial physicians can find themselves legally accountable, if their action or omission constitutes negligence. Four elements must be proved before a patient can recover from a physician's negligence:

1. There must be a duty owed to someone.
2. That duty must be breached.
3. The person to whom the duty is owed must sustain some injury.

4. That injury must be proximately caused by, or directly related to, the breach of the duty.

Considering the above, the first question is, "To whom does the industrial physician owe a duty?" In order to facilitate the handling of occupational medical problems, the employer or the workers' compensation insurance carrier usually engages the services of a physician. In most cases this is done by written contract. The physician's duties are described in the contract. In addition, as pointed out by the Hoover case, the physician also has a duty to employees where he undertakes to render medical services. This exists even though the employees are not parties to the contract.

The next questions which arise are: What is the nature and extent of the duty owed to patients and others; and what constitutes a breach of this duty? The responsibility of the professional is to conform to the standard of care maintained by other competent professionals with comparable education and training in the same or similar circumstances. This is the standard on which nearly all professional liability suits are decided.

In determining whether or not the industrial physician has maintained the acceptable standard of care, evidence of the proper standard may come from various sources. Testimony of other industrial physicians within the community and recognized experts in the field may be used. Federal and state laws and regulations, city and county ordinances, and industrial standards may be relevant to providing the standard of care required. Once the standard is established, performance not meeting the standard would constitute a breach of that standard.

The third factor necessary for legal liability from negligence is, that the person to whom the duty is owed must suffer some damage. One way to assess the extent of damages suffered is to determine the economic loss suffered as a result of the "negligent" act. "Pain and suffering" alone are not sufficient proof of injury. It is the responsibility of the person bringing a lawsuit to show the extent of his physical or mental injuries.

The fourth element of liability is that the damage be "proximately caused" by the negligent breach of the duty owed. If there is no damage, or if damage is totally unrelated to professional negligence, there is no professional liability. An example of this may be seen in a Texas case. There, a terminally ill hospital patient's death was hastened by burns received as a result of a fire in his hospital room. The Texas Court of Civil Appeals observed that the hospital was negligent in not properly training its personnel in fire fighting. This negligence was not the cause of the patient's death, however, because no one could say the patient would not have been injured if the fire had been extinguished sooner. Therefore, the hospital was not liable (1).

WHO MUST PAY FOR MEDICAL NEGLIGENCE?

In the usual medical malpractice case, if the patient meets the four elements of the burden of proof, the defendant physician pays. Where workers' compensation is involved, the result may be different. In some cases the outcome may hinge on whether the physician is considered an employee or an independent contractor. A number of states immunize co-employees from the category of "third persons" that may be sued (2). A typical provision of the state law would be as follows:

> "The right to compensation or benefits under this (workers' compensation) chapter shall be the exclusive remedy to an employee, or in the case of death his dependents, when such employee is injured or killed by the negligence or wrong of another in the same employ." (3).

In some states that have statutes similar to the one above which excludes co-employees as sueable third parties, a physician employed by the same employer as the plaintiff has been held to be protected.

In New York, a physician is considered to be a fellow employee if he is engaged as an employee to treat other employees, Garcia v. Iserson, 309 N.E.2d 420 (New York, 1974) and Galini v. Nachtigall, 359 N.Y.S.2d 879 (N.Y. Sup. Ct., App. Div., 1974).

In states where the employed physician may not be required to pay the claims for medical malpractice of fellow employees under exclusive remedy statutes, the physician may still be required to make restitution. Section 72.62 of the treatise, Larson's Workmen's Compensation Law states:

> "... (S)ince the employee's inability to sue usually means only that, by accepting compensation, he has set in motion the subrogation or assignment provisions of the third-party statutes... (I)t usually follows that the employee's full rights can still be enforced against the physician by the subrogee employer or insurer, with the employee getting the excess of the recovery beyond what is necessary to reimburse the payer of compensation. Of course, the subrogee may realistically have less incentive to sue the physician than the employee would have, especially when the physician is associated with the employer or insurance company."

Because of the possible right of subrogation, the question of professional liability insurance coverage should be considered in any employment contract. It is also an important item to be included in contracts between an employer and an independent physician.

CONCLUSION

The relationship between an industrial physician and a prospective or actual employee to be examined is not the usual doctor-patient relationship. The physician owes no duty to discover conditions requiring medical treatment. However, if the doctor undertakes to advise an examinee, thereby causing the latter to rely on the doctor's services to his detriment, liability may attach. Additionally, if conditions requiring medical treatment are discovered, an obligation to disclose this information to the examinee arises.

The above rules cover situations where the person examined is not healthy. Problems also arise where the person examined is healthy but is wrongfully found to be unhealthy by a physician. A physician is liable for injuries or losses caused by his finding of ill health, where the physician fails to exercise required care and diligence. Lesser mistakes, as where an examining physician fails to qualify his findings in accordance with good medical standards, have been found not to impose liability.

Even though the relationship between an industrial physician and a prospective or actual employee is not the usual doctor-patient relationship, it is a very rewarding and challenging area of medicine. As interest continues to grow in employees' safety, the role of occupational medicine will expand. This growth will produce complex questions, some of which will involve professional liability. Some of these questions cannot be answered definitively now, but the years ahead should be far from dull.

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PROBLEMS IN OCCUPATIONAL HEALTH PROGRAMMING

Loren L. Hatch, DO, PhD

Good Afternoon Ladies and Gentlemen. I was asked by Dr. Jack Finklea, Director of the National Institute for Occupational Safety and Health (NIOSH) to extend greetings and offer apologies for his inability to join you. Mr. Cyrus Vance, Secretary of State, asked him to meet with a Polish official to discuss problems of mutual interest. He regrets he cannot be with you today, share some thoughts, and experiences and thanks the AMA for their invitation.

NIOSH problems in occupational safety and health programming are nationwide - yet we reach into the smallest plant. To give you some idea of the scope of the problem, remember there are more than five million businesses in the United States who employ some 85 million persons. However, 4 1/3 million of these businesses employ 25 or fewer workers. You can guess that it is in the smaller workplaces where many of the more severe occupational safety and health problems exist, where programming is often the most difficult, - and where you can help the most.

Many smaller businesses do not have the time, manpower, expertise or financial resources to initiate and carry out effective occupational safety and health programs. Therefore, the first programming problem is one of establishment size. Please allow me to give some statistics to show why small businesses cannot keep up with occupational safety and health programs.

Last year the NIOSH Registry of Toxic Effects of Chemical Substances listed almost 22,000 different chemical substances with three times that number in synonyms, tradenames and codes. Those of you who have seen or heard testimony regarding the National Occupational Hazard Survey know we estimate 21 million workers are exposed to OSHA-regulated substances and only slightly less than a million workers are exposed to one or more of the 16 carcinogens currently regulated by OSHA. Perhaps 45,000 of these workers are exposed four or more hours each working day to one of these carcinogens. If this isn't serious enough, there are about 43,000 tradename products which we have identified, but whose composition is not known by the companies using the product. These figures are only estimates. This leads to a second problem, which is deficiencies and inadequacies in the reporting of work-related diseases. The National Safety Council and the U. S. Public Health Service, have made other estimates. In 1975, 12,600 persons died as a result of occupational injuries and another 2.2 million persons suffered permanent or temporary disability. In 1974, 3.7 million persons required medical treatment as a result of workplace injuries. The cost of all of this to society is about $16 billion annually, and these costs are primarily for injuries.

We also have problems with individual companies, even those in the Fortune "500," and it is in these companies that we experience our third programming problem, credibility. Not NIOSH credibility, but credibility between the employees and management as represented by the medical department.

For example, I recently received a telephone call from a union steward in an eastern company which manufactures electrical generators. NIOSH has a procedure in our Health Hazard Evaluation program for obtaining free consultation, and his request qualified.

I went to the facility, conducted interviews with the workers, performed a short physical examination, and took photographs of the workers' problem. It seems the workers' hands were swollen, fissured, and in some cases bleeding.

The problem was three-fold. First, nobody knew what was causing the problem, which had just begun. The first thing we look for in this situation is any change in process, and indeed the company had switched suppliers of their epoxy resin, which was used to coat each wire as it was laid in place in the generator to provide insulation. The nature of this work is such that no gloves or barrier creams or other protection is possible. It was hard, heavy, dirty work and consisted of dipping cloth wrappers into the epoxy solution and wrapping wires and other points of electrical contact.

To be on the safe side, I patch tested the workers and a group of controls; nothing happened. Back to the drawing board. We questioned the workers and management for other changes they had instituted recently but there were none. It became necessary for me to dig out my overalls, put on my safety shoes, hardhat and goggles and go through the production process. At the end of two days' observations, as I was about to leave the worksite at the end of a shift, I noticed individual workers were cleaning their tools. The plant did not have a tool crib, but the workers were issued tools when they were first hired, and they were expected to keep and maintain them.

Each group of 8 to 10 workers had a large pot in which they would dip their tools, wash them off, and put them away until the next shift. Obviously some of the solution splashed on the skin of the workers and I thought, "Well, we've got the problem solved." Upon closer questioning, I found that the men were not only using this solution to clean their tools, but every time throughout the work shift that some of this epoxy splashed on their skin, they were sticking their hands in the solvent to clean them as well. We patch tested the workers for sensitivity to the solvent and discovered the problem.

Secondly, why didn't the workers report their dermatitis to management or to the medical department? Because of the highly detailed and technical nature of the work, these people received an hourly bonus, and if they reported to the medical department, they would be removed from the job and lose an extra $500.00 a year of wages and another $1,500 from overtime. The loss of $2-3,000 in a year is considerable.

What we attempted to do with some degree of success was to convince management and the medical department that when these people report to them, if they reported early, it was a matter of treating them and there was no need to transfer these specialized workers and train new ones all over again. In addition, we convinced management they should tap into the hot and cold water lines that extended throughout the worksite and put in wash basins, so the workers could wash their hands immediately with soap and water when the resins splashed on the skin, instead of using solvents.

I learned later management and the union are cooperating fully, and therefore a problem has been averted which would have shut down the plant, causing costs of untold thousands of dollars to society who were waiting for these generators.

Here was a plant with more than a dozen physicians, many nurses, a fully staffed industrial hygiene department, and several safety professionals. Obviously, the problem was one of lack of communication and credibility. The physicians had not taken the time to visit the plant to see what the problem was, and the men did not believe they could be treated without losing extra income. I cannot stress strongly enough that it is necessary for physicians, and for the nurses as well who are often more adept at spotting problems, to shed periodically their white attire and see what the workers are doing and the conditions under which they are doing it. In this case, it certainly wasn't a lack of time, expertise, manpower or financial resources.

On the other hand, management, as represented by an industrial hygienist in a small company in the Rocky Mountains, called me because workers were staying off the job more than his previous experience indicated they should. This was an easy problem, and on the first walk-through we spotted fumes from the cadmium plating operation. We outlined possible controls, administrative, engineering, and through personal protective equipment. Instead of spending thousands of dollars on correction, the company jobbed out the process to a plant with more experience in this operation and adequate contols. This case did not represent a problem in occupational safety and health programming, unless you accept administrative controls as programming.

As you can see from these two cases, the incidence and prevalence of occupational illnesses are less appreciated than those of occupational injuries. Workers and management can readily see the results of occupational injuries, and both groups have guarded against them for many years. This may be for economic reasons, because while the loss to the worker is tremendous, it is even greater for management, when one considers that indirect costs of occupational injuries are estimated at 3 to 7 times those of the direct costs.

A recent NIOSH survey of medical conditions in selected small industries in Oregon and Washington found the prevalence of probable occupational disease was 28.4 per 100 workers. Last year, an interdepartmental workers' compensation task force conference on occupational diseases and workers' compensation estimated as many as 100,000 excess deaths are occurring each year as a consequence of occupational disease. Of the 80 or 90 percent of cancer which can be broadly classified as environmentally caused, there is concensus that occupational factors play an important role. Of continuing concern for the future, are chronic diseases of the respiratory system such as silicosis, asbestosis, pneumoconiosis, byssinosis, stannosis and others.

The NIOSH National Occupational Hazard Survey indicated 31% of the plants surveyed, which employed 24% of the workers had industrial hygiene services, and 4% of the plants employing 31% of the workers had formally established health units. Statisticians have estimated that only 2% of the employees in the 4 1/3 million small U.S. businesses have access to industrial hygiene service and workplace monitoring programs. This is where you come in.

As more physicians and nurses, both full time and part time, become knowledgeable of potential workplace hazards, there is greater likelihood societal costs can be reduced, the economic efficiency of the United States can be improved, and workers will have safer and healthier worksites.

This brings up another occupational safety and health programming problem - failure to recognize diseases and injuries that may be related to occupations. This failure may be one of physicians working in industry, but more often is demonstrated by interns, residents and general practitioners staffing emergency rooms and by multi-specialty group practice members. An adequate occupational history should be a portion of every medical record in the United States, whether in the physician's office or in the hospital.

This leads to another programming problem: failure of medical faculty and state licensing boards to include occupational medicine in their curricula and examinations. Occupational medicine has a relationship to virtually every field of clinical medicine, especially preventive medicine, yet physicians and nurses rarely are trained to take occupational histories. Nor do they usually take occupational factors into consideration in their diagnosis. In the field of oncology alone, as well as with other chronic diseases, chemicals in the work environment must always be considered.

Another NIOSH program characteristic is a gap in problem recognition due to inadequate surveillance, for identifying hazardous exposures as well as for assessing adverse effects resulting from these exposures. It would be ideal if every physician and nurse working in occupational medicine, for example, took a course or bought a book on basic epidemiology, conducted studies of their own, and reported positive findings.

One of the main difficulties in program planning is, workers and employers are frequently unaware of the toxins to which they are exposed. This is in part due to trade name products which are not labeled as to composition. When a company tells us their product is a trade secret, it seriously hampers our ability to effectively use this information to assist in occupational health programming. This is a needless and difficult problem and a tremendous waste of resources. If we want to know badly enough we can obtain information about product composition, but the information then is available only to us, which prevents us from effectively applying the knowledge to the safety and health of workers in other companies, who may use the identical chemical under a different name.

Other NIOSH programming problems occur in the critical area of program evaluation. As our knowledge in the field of occupational medicine expands, so does the recognized potential for worker risk. With the influx of women of childbearing age into the work force, potential hazards to the fetus have increased, including teratogenic and mutagenic effects associated with occupational exposures. Since most carcinogens are also suspected of being mutagens, the magnitude of this potential problem is substantial. Not to be overlooked are the potential toxic effects on reproduction through exposure of the father.

A related programming problem is the conflict between competing national goals of equal employment opportunity and protection of worker health. In the absence of adequate engineering controls, women of childbearing age are being transferred or even excluded from jobs which may have exposure to toxic agents.

The whole field of occupational endocrinology is relatively unexplored. You are familiar with the problem of the organo-phosphates in the James River due to the dumping of kepone. Another pesticide formulating problem with phospol raises questions about similarly acting substances. The entire issue of behavioral changes induced by chronic low level exposures to chemicals is only in an early stage.

Last February I was in Northern Montana on an Indian reservation where the Indians were operating a plant under military contract. They were having respiratory problems which ultimately turned out to be due to tin oxide. It was 30 below zero and the chill factor must have been minus 100, or at least it felt that way. In this remote area, Doctor Finklea found me and sent me to Houston, Texas, where the weather was a hot 90 degrees. There were 10 minutes between a plane change in Cincinnati, where I transferred a suitcase of dirty clothes for clean ones, met another medical officer, and we began to work on an organo-phosphate problem.

The particular problem was the subject of a twenty minute segment by Sixty Minutes. It involved a small plant, which was formulating organo-phosphate pesticides for shipment overseas. Here the problem was not one of lack of expertise or manpower or resources on the part of the company, but one of too little knowledge available on the neurotoxicity of phosphol.

Obviously it would be nice if we had the ability to predict toxicity based upon chemical structure alone, but until this knowledge becomes more precise, we have to count on you to assist us in rapidly recognizing the work-relatedness of disease. And when new potential hazards are discovered, which have in fact gone unrecognized for years, you can play a further role by providing expertise in the medical follow-up needed for workers exposed in the past.

Another problem in occupational safety and health programming is an inadequate number of qualified safety and health professionals. It is conservatively estimated that an additional 1,000 certified occupational physician specialists and approximately 20,000 physicians with short term occupational health training, serving primarily as part time occupational health physicians, are needed to meet the minimum professional manpower requirements. A deficit of 4,000 certified industrial hygienists, 4,700 safety professionals and over 25,000 occupational nurses exists. Your presence here indicates that you and the AMA Congress are doing your part to improve short term occupational health training.

Currently, few schools of medicine or public health offer a formal residency in occupational health, and even fewer medical schools include occupational medicine in their programs.

Presently there is no coordinated effort to link the education and training of health and safety professionals. Outside of NIOSH training, few opportunities exist. The American Occupational Medical Association in Chicago also holds training programs, although my personal observation is their education is primarily directed toward the full time corporate medical director.

A final program planning problem is coordination of the work of other national organizations with NIOSH. Some of these are the National Cancer Institute, National Heart, Lung and Blood Institute, National Institute of Neurological and Communicative Disorders and Stroke, National Center for Toxicological Research, The Alcohol and Drug Abuse and Mental Health Administration, the Health Resources Administration, and others. The Department of Defense is also actively involved in occupational safety and health.

I believe the incidence of work-related disease could be reduced significantly if it were possible to eliminate cigarette smoking, alcohol-drug abuse, and obesity by American workers. It is frustrating to program for occupational safety and health, when in many instances the habits of employees work against their own occupational safety and health.

In summary, many plants lack expertise, time, manpower, and financial resources to plan an effective occupational safety and health program.

1. There are existing inaccuracies and deficiencies in the reporting system for work-relatedness of disease.
2. Credibility remains a problem between health units and occupational physicians and management; management and unions in the area of occupational safety and health; and workers and management, with the latter requiring

the wearing of awkward personal protective equipment and not understanding the reasonableness of certain work practices.

3. Recognition of work-relatedness of disease remains a tremendous problem among health care delivery systems and individual physicians and nurses.
4. The lack of occupational medicine training through medical school curricula, continuing medical education, and short term occupational medicine training courses for physicians and nurses remains a deficiency.
5. Hazard identification until corrected will remain a serious barrier to the safety and health of American workers.
6. Program evaluation is being solved as specialists in toxicology and organ systems meet in conferences and through their writings to exchange knowledge. Millions of dollars have been spent on cancer research, but little direction has been given to possible work-relatedness of cancer.
7. Resolution needs to be achieved through guidance from the legislature on the conflict among competing national goals. As progress is made in one field, it may work to the detriment of another national goal.
8. The problem with the inadequacy of the number of professionals in occupational safety and health is only slowly being addressed. Your efforts through your medical school alumni ties and state licensing boards in this area is needed.
9. National coordination is needed through administrators of programs to avoid duplication of effort and to develop a concerted effort towards expertise in each organization.

PROBLEMS IN OCCUPATIONAL HEALTH PROGRAMMING

The Benefit-to-Risk Ratio in Occupational Health

Lewis C. Robbins, MD

In all problem solving one must first define the problem. I should like to propose what I believe the employer sees as his problem, and attempt to define it.

To use Buckminster Fuller's definition, the employer is concerned with the probable recurrence of yesterday's crises. The employer's problem is loss of continuity of employment brought on by diseases and injuries. The working employee is not ill. But the employer knows that he is at risk.

Before the legitimate complaint, there is genesis of disease and injury. Prospective medicine proposes that this risk, and the degree to which it can be reduced, be estimated for each individual. This provides a broader view of medicine, namely, a benefit-to-risk ratio for the well <u>and</u> for the sick.

Prospective medicine uses the benefit-to-risk ratio to improve the employer's chances for continuity of employment among all employees. This differs from today's medicine in that prospective medicine investigates prognosis of the well in addition to the sick.

Some physicians say there is no validity to a discipline that attempts to evaluate the well. But life insurance companies know actuaries can estimate risk, and they have invested a trillion dollars in their estimates. Some say medicine cannot take a prospective view, but many physicians are already providing preventive programs to the well. We would go one step farther in prospective medicine and offer interventions which will reduce the total personal risk. We propose to the employer that prospective medicine is a search for survival advantage, an attempt to reduce risk. The employee health program of the future will seek this survival advantage.

On what foundation was prospective medicine built? There is a common denominator for both curative and prospective medicine, and that common denominator is "risk." The numerator is the "benefit," or reduced risk. The benefit to risk ratio has been called the "survival advantage," which is usually expressed as a ratio, or rate, e.g., "The risk can be reduced by 75%." The employer cannot afford to omit important benefit-to-risk ratios from his health program.

How is the employer to gain better health for employees? Can valid benefit to risk ratios be ordered in such a way as to give all possible survival advantages? In 1970, a group of physicians at the Methodist Hospital of Indiana, acting under a grant from the Indiana State Board of Health, published a manual called, "How to Practice Prospective Medicine." This manual sought to define problems in the well person in terms of the risk of death within ten years. The point is to determine how much this risk can be reduced.

To those who say our present state of knowledge does not permit this precision in the practice of medicine, we say that science has collected the necessary data, and medicine can apply this science in a way that changes the usual course. Health hazard appraisal presents results in terms of changing long term risks in an individual, giving high visibility to the process by means of the health hazard appraisal (HHA) chart. Let us examine this art through the chronology of its development.

In 1947, the Public Health Service (PHS) received a mandate from Congress to begin work on the control of heart disease. Dr. Joseph Mountin chose to initiate a prospective study of heart disease and to include a preventive program that would exploit this and other prospective research. The writer was one of two physicians who were assigned to this study-control effort. The resulting demonstrations became the Framingham and Newton studies. Markers, risk factors, or precursors were identified that placed people at higher risk of coronary heart disease. But were they valid?

As the data from the Framingham study appeared, epidemiologists began to set up studies to confirm them. There was debate, and eventually the question was asked: Shall we go to the profession and to the public with our findings? Some precursors were validated, others were not.

In addition to the precursors of coronary heart disease, precursors for diseases and injuries began to appear. PHS and the American Cancer Society began to help identify those at high risk. When such an amount of strong evidence had collected, it seemed the medical profession and the public should be informed. PHS did this, and the first major warning was on the cigarette and its relation to lung cancer.

One of the two epidemiologists who reported the cigarette-lung cancer relationship, Dr. Daniel Horn of the American Cancer Society, proposed the term, "survival advantage." The difference between the benefit and the risk can be called an advantage in survival.

The risk factors of cigarettes to lung cancer, cigarettes to coronary heart disease, and alcohol to motor vehicle crashes were recognized as valid precursors that held survival advantage, and scientific societies began to recognize those who were competent in presenting the evidence about precursors and survival advantage.

The Surgeon General of the PHS asked the writer, who was then Chief of the Cancer Control Program (CCP), how he planned to adapt cervical cancer control to medicine. I then began to put together the contributions of those who had pioneered in exploring the natural history of common diseases. Could these several persons, knowing one precursor well, work together to put prevention into practice?

Once the means appeared through resources of the Cancer Control Program to bring the several precursors into a preventive program, a population base was sought for the risk factors. There are three important variables among Americans which affect their risk: age, sex, and race. Harvey Geller of the Cancer Control Program designed tables that gave the 10-year risk of death of individuals in specific age and sex groups by race.

We believed a person's 10-year risk should be examined, so that diseases and injuries could be anticipated in time through the identification of precursors, and their staging, prognosis, and treatment. What are the premature deaths in one's age group? Just how great, on the average, is the risk of death from major causes, by age, sex and race? These tables became known as the Geller Tables, and they have been used to demonstrate the objectives of health hazard appraisal.

One of the advisory physicians on the Cancer Control Program was J. P. Lindsay, Chairman of the Education Commission of the American Academy of General Practice. We discussed with him and others whether this effort, to begin with precursors and to reduce risk, should be developed by public health officers, occupational health physicians, or practicing physicians. Doctor Lindsay believed beginning with practicing physicians would explore a likely source of support, and that the general practitioners were the only ones who hadn't excluded themselves by specialty claims from seeing patients prospectively.

There comes a time when one must advance from discussion to demonstration. Dr. John Hanlon, then chief health officer in Philadelphia and professor of preventive medicine at Temple, was asked to test the appraisal, using the Geller Tables and the valid precursors. A medical student, now Constance Bonbrest, M.D., was assigned as a student employee to the outpatient department of the medical school. During the summer of 1959, 25 appraisals were done, called "health hazard charts". We then looked at the charts and found ways to improve them. The biggest problem was in telling people what we had done, but at least we had a demonstration.

Following the pilot Temple University study, with Doctor Hanlon and others we held a two day discussion of what had been achieved. Our health educator, Cecilia Conrath, said what we were doing was putting prospective studies into practice, and why wasn't that "prospective medicine"? From that moment on, we had no difficulty in telling what it was we were trying to do.

A test of the new term, "Prospective Medicine" aroused interest and enthusiasm among medical students, physicians, and preventive medicine people. Dr. Thomas Peery, who directed the screening of physicians at the annual meetings of the American Medical Association, was approached with the proposal that a demonstration be attempted at George Washington University. He brought in Dr. Joseph F. Sadusk, Jr., who in a few months had organized a demonstration involving internists, medical students, and a reviewing body of specialists to provide benefit-to-risk ratios. One hundred outpatients received health hazard appraisals, and the program was reported in The Journal of the American Medical Association (1). Here was the modern "Flexner Specialist" contributing to a new medicine.

The Cancer Control Program believed the American Academy of General Practice (AAGP) had the greatest impact on U.S. primary care. Amos Johnson, who later became the President of the American Academy of General Practice, helped to improve professional education in the Academy about cancer and proposed we develop a demonstration to show the family doctor was interested in preventive medicine. With the help of Drs. John Heller and Ulrich Bryner a program was proposed to the AAGP to work with the Cancer Control Program in demonstrating cervical cancer through the general practitioner. Within four years, 1.7 million Pap smears had been taken by 5,000 family doctors, and 10,000 cervical cancers had been diagnosed. This achievement was of help to the Academy in their bid for a new specialty in family practice.

With the family physician showing interest and competence in prospective medicine, more tools for him were sought, and Phillip George, now a surgeon in Miami, joined the Public Health Service to work with the writer on a health hazard appraisal chart. This chart was designed to present the benefit-to-risk ratios of several precursors in such a way that the total personal risk could be determined.

The chart was to be used as a model that would permit a determination of the individual's need for preventive medicine. As it was being developed, the Millis Commission, and coincidentally the Willard Committee, Ravdin, and Witten groups, began to study the integration of medicine into a comprehensive whole through the services of a new kind of practitioner, the primary or family physician.

The epidemiologist had made great contributions to prospective medicine through the work of identifying valid predictors. He did not show, however, how these benefit-to-risk ratios could be used in determining the total personal risk. When actuaries were asked if risk estimates could be made from the grouped data, they assured us that this was their daily work. Then Norman Gesner took on the job of putting together tables that would combine the average risks by age, sex, and race, according to precursor, stage of precursor, and interventions.

Life insurance companies had broad experience with determination of total personal risks and with changes in risks and precursors. Their method of risk estimate was called the credit-debit system. It consisted largely of adding debits in the form of percentage increases to the age risk. These unique tables developed by Norman Gesner were called the Geller-Gesner Tables.

The health hazard chart came at a time when the computer was coming into its own. Robert Manning, Professor of Medicine at the University of Kansas, was the first to computerize health hazard appraisal (HHA) in 1969. Doctor Manning used the computer to teach medical students how to begin the practice of prospective medicine. Today, two of the best examples of this computerization are the inter-health program in San Diego and the HHA's which are part of the Lifestyle program in The Department of Health and Welfare in Canada. The latter is described in the book "A New Perspective on the Health of Canadians" by Mark Lalonde.

As new developments appear, the directors of medical education in community hospitals must find ways to include them in teaching programs. Jack H. Hall, Director of Medical Education at Methodist Hospital, Indianapolis, developed a teaching program in HHA with the help of a grant from the CCP. The writer joined him as chief of HHA and wrote a manual about the performance of these appraisals. The manual was developed with the help of 12 task forces made up of family doctors at the hospital.

Is there such a role as "precursor specialist"? What is meant by this term is a health worker, preferably a physician, who has specialized in the natural history of a precursor sufficiently to advise authoritatively about its control. The physician generally needs others to help him, for precursors are as varied as alcohol as a factor in motor vehicle crashes and cigarettes in stroke. The physician also is needed to help in the update of the Geller-Gesner Tables and to help build supports for the practice of prospective medicine.

The writer is one of many who knew one precursor well enough to help plan control programs. The precursor specialist deliberately seeks others to help design programs that anticipate disease or injury related to the specific precursor.

The following are 24 precursors selected for their major importance in the practice of prospective medicine:

Cigarettes to coronary heart disease
High blood pressure to coronary heart disease
High cholesterol to coronary heart disease
Sedentary life to coronary heart disease
Diabetes to coronary heart disease
Obesity to coronary heart disease
High blood pressure to hypertensive heart disease
High blood pressure to stroke
Cigarettes to lung cancer
Cigarettes to bronchitis-emphysema
No seat belt to motor vehicle crash injury
Alcohol to motor vehicle injury
Miles traveled to motor vehicle crash
Alcohol to cirrhosis
Depression to suicide
Positive cytology to cancer of the cervix
Carrying weapon to homicide
Arrest record to homicide
Rheumatic fever to rheumatic heart disease
History of colonic polyp to cancer of colon-rectum
Occult blood in stool to colon-rectum cancer
Family history to breast cancer
Dominant nodule (lump) to breast cancer
Mammography (cancer image) to breast cancer

How does all this relate to occupational health? The employee is a patient who has a vantage point that no one else has, for he can say, "I'm the only one who knows when my shoe pinches." Since workers should see the world as largely indifferent or hostile to their welfare, they must assume responsibility for their acts, and understand that they can contribute to long and useful life expectancies.

The medical profession teaches the patient very little about the anticipation of major causes of death and disability, risk precursors, and their relationship to the natural history of disease and appropriate intervention. Medicine must help develop guidance programs for the patient that are commensurate with its mission: the preservation of youthful and useful function. The several hundred thousand patients using HHA have almost universally found it helpful.

One of the recurring questions in occupational health is whether to take over the responsibility for providing medical care to the employee. Most programs reluctantly conclude, several times a year, to continue to play a supporting role to the family doctor. There is a way to play this role with both the employer and the family doctor as the beneficiary. HHA is designed to provide to the physician all possible patient information. It can provide continuity to the employer in significant problems. The family doctor can be offered a data base that will give his patient the best advantage, whether the diagnosis is of a precursor or of a disease. Here is a way for occupational health to win with every patient: perform a HHA and then help the patient enter into a risk reduction program based upon specific health education.

Information about HHA and prospective medicine is available from the Methodist Hospital, Indianapolis, Indiana 46202.

SUMMARY

Prospective medicine has been summarized best by William P. Richardson, M.D., a past president of the American College of Preventive Medicine:

> "In its early days health hazard appraisal was, somewhat disparagingly, called a 'numbers game.' It is indeed a 'numbers game' in the highest and best sense of that term. So also are curative medicine and public health, each of which measures its success by its benefit to risk ratio. In curative medicine the risk is the deaths from a particular disease or injury which can be expected without treatment, and the benefit is the number by which these expected deaths

are reduced by appropriate treatment. In public health the risk is defined in terms of deaths in a population which has been followed prospectively, and the benefit is the reduction in deaths brought about by a specified intervention, i.e., purification of a water supply or pasteurization of milk.

"It is obvious that both of these approaches have achieved great successes, but both have also been limited by the way in which they have been practiced. Curative medicine begins with the sick individual and seeks to reduce his risk, his chances of dying from his disease. Public health begins with the group and seeks to reduce deaths by interventions directed at the group or community. Both approaches fail to take account of the role of the individual in determining his own health.

"Health hazard appraisal transcends these limitations of both medicine and public health: of medicine by starting with the individual while he is well, and of public health by recognizing the individual as the ultimate decision-maker, and focusing on what he can do to enhance the chances of his own survival. It defines the risk as the chance of the individual's dying over the next ten years, based on the mortality experience for his age-sex-race group. The benefit is the increased chance of survival he can bring about by changes in life-style, to eliminate or reduce the risk of overt disease and death posed by specific precursors of disease.

"The benefit to risk ratio for both curative medicine and public health are basically determined by professional prognoses and decisions made on behalf of the individual or group. The benefit to risk ratio in health hazard appraisal is determined by decisions the individual himself makes.

"In short, health hazard appraisal broadens medicine's 'numbers game' to include as the R (risk in the B/R ratio, precursors of disease in the well individual, and as the B (benefit) the survival advantage from measures of intervention for which the individual must assume responsibility. Guidance as to the appropriate measures and the decision to assume this responsibility must necessarily be based on sound scientific information provided in terms which the individual can understand and which will motivate him to make the necessary changes in habits and life-style.

"We have done a very poor job of providing such information and motivation to the individual. The educational effort it will require is an awesome one which challenges the best efforts of practitioners of curative medicine, public health and health hazard appraisal alike."

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